Precautionary Savings and the Stock-Bond Covariance

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Abstract

I show that the precautionary savings motive can account for high-frequency variation in the stock-bond covariance. An increase in the price of risk lowers risky asset prices on account of an increase in risk premia; it lowers bond yields on account of the precautionary savings component. Consequently, a price of risk shock moves risky and safe asset prices in the opposite direction. Times when the price of risk is *volatile* see a more negative stock-bond covariance. I demonstrate that a model calibrated to match the equity risk premium fits well the recent evidence on stock-bond covariance. Empirically, I show that stock-bond covariance co-moves with credit spreads and can predict excess returns on risky bonds and on bond-like stocks. The calibrated model underlines the first-order effect of risk compensation on safe rates.

1 Introduction

The stock market exposure of long safe assets has changed a lot in recent data. First drifting into negative territory before the turn of the century, the stock-bond covariance was substantially negative during the Global Financial Crisis. There have been periods of substantial negative spikes in the stock-bond covariance outside the crisis period: notably in 2002-2003 and in 2011-2012. What is more, both nominal and real bonds have exhibited strikingly similar time variation in their exposure to stock market returns. I graph the recent behavior of the stock-bond covariance in Figure 1. As the Figure shows, both nominal and real Treasury bonds have been good hedge assets in bad times.

While it is straightforward to calibrate a standard model to exhibit either a positive or negative stock-bond covariance, it is tougher to match the high frequency changes. In this paper I show

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that such high-frequency variation in the stock-bond covariance arises naturally in any model with time varying volatility in the price of risk. The intuition is simple: the price of risk affects risky and safe asset prices in the opposite direction. Stock prices are decreasing in the price of risk on account of the risk premium term; bond prices are increasing in the price of risk on account of the precautionary savings term. Any increase or decrease in the price of risk, then, sees the stock and bond prices move in opposite direction. Consequently, times with high *volatility* in the price of risk process see a more negative stock-bond correlation.

In order to formalize this intuition, I write down a term structure model that features two state variables: the price of risk and the aggregate dividend growth rate. I follow the approach in Lettau and Wachter (2007) and directly assume a price of risk process. By model assumption the price of risk process displays time-varying volatility, while the variation in the forward-looking dividend growth rate has constant volatility. As a result, the relative share of volatility stemming from the two state variables changes over time. For reasons of tractability I specify that the price of risk follows a square root Cox, Ingersoll Jr. and Ross (1985) (CIR) process, and that dividend shocks are proportional to the price of risk. With these assumptions both the precautionary savings term of safe asset prices and the risk premium term of risky asset prices are affine in the state variables, allowing me to recursively derive in closed form the term structure of stock and bond prices.

With the recursive model solution in hand, I calculate the implied stock-bond covariance. I show that under a price of risk process that matches the aggregate equity risk premium, the model delivers a stock-bond covariance that fits the empirical counterpart in the recent sample. The assets I study–the aggregate stock market and a long maturity bond–have constant loadings on the two distinct sources of risk in the economy. However, the relative share of total volatility stemming from the two state variables changes over time. This represents a departure from the existing literature which tends to focus on time-varying attributes of the assets themselves. In the model presented here, times when the price of risk is volatile see a large share of the fluctuations in aggregate valuations stem from changes in the price of risk. Times when price of risk is stable the divided growth rate shocks contribute relatively more to the variation in valuations. Because I use a CIR process for the price of risk, it is volatile precisely when it is high and the model stock-bond covariance tends to be more negative in bad times, just like in the data.

In practice many standard asset pricing models assume away the precautionary savings term for analytical convenience. One well-known example is Campbell and Cochrane (1999) where the functional form of the habit formation process ensures that the precautionary savings term of the risk-free rate exactly cancels out the intertemporal substitution term. Similarly, in Lettau and Wachter (2007) the risk-free rate is assumed to be constant at all maturities, despite the time variation in the price of risk. I show that the inclusion of the precautionary savings term materially alters the stock-bond covariance in the model—though in many settings the inclusion of this term comes at the cost of analytical tractability.

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In addition to being able to match the time variation in the stock-bond covariance, the model is consistent with a number of other empirical regularities.

First, I show that the stock-bond covariance co-moves with the level of aggregate credit spreads. Times of negative covariance—which according to the model are also times when the level of risk premia is high—see high credit spreads of safe over risky fixed income assets. Stock-bond covariance has a "level" effect on safe interest rates: large negative covariance episodes tend to see lower interest rates across maturities, corresponding to the level factor in interest rates. Cochrane and Piazzesi (2009) demonstrate that excess bond returns are earned in compensation for exposure to the level factor shocks. Correspondingly, the stock-bond covariance predicts excess returns on long maturity Treasuries as well as excess returns of risky fixed income assets over equivalent maturity Treasury returns.

Secondly, I show that the stock-bond covariance is a good predictor of "bond-like" stock returns: stocks that have low volatility, are profitable, are mature, or pay dividends. I construct long-short portfolios of bond-like stocks following Baker and Wurgler (2012) and show that times of high negative stock-bond covariance are followed by low returns on such bond-like stocks, indicating that such stocks are highly valued at times of negative stock-bond covariance. This predictability remains statistically significant controlling for other bond return predictors.

Thirdly, I show that the composition of aggregate bond issuance reflects time variation in stock-bond covariance. Namely, in times of negative stock-bond covariance investment grade issuance represents a higher share of total issuance. This is consistent with the finding that credit spreads tend to open up in negative stock-bond covariance times. Further, the stock-bond covariance can also account for sectoral holdings of safe assets. During times of negative covariance broker-dealers tend to increase the holdings of Treasuries.

Fourthly, employing options data on Treasury futures I measure implied volatility and jump probabilities of Treasury bond prices and show that times of high implied volatility of rates and high probability of a jump in Treasury prices (a flight-to-quality episode) coincide with negative covariance episodes.

Finally, I show there is substantial co-movement in the local stock-bond covariances calculated in different developed economies. The local currency stock and local currency bond return covariance in Germany, U.K., France, and other countries closely follows that calculated using the U.S. data. I interpret this finding as evidence in favor of substantial international risk-sharing, as argued in Brandt et al. (2006). I show that periods of large negative stock-bond covariance in the U.S. are followed by the appreciation of foreign currencies over the USD, consistent with a flight to the dollar in bad times.

A number of recent papers have studied the stock-bond covariance. Kozak (2015) specifies a production economy where two distinct production processes differ in riskiness and adjustment

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costs. One of the processes has relatively safe cash flows, the other relatively risky cash-flows. In addition, the model features time-varying risk aversion which affects the relative valuations of these two production processes. By the two-tree mechanism described in Cochrane et al. (2007), the aggregate market covariance with bond returns is rendered time-varying.

Likewise, the model presented here can account for the variation in the stock-bond covariance without relying on inflation dynamics: the results obtain in a purely real model. The majority of other existing work has attributed the variation in the long bond risk exposure to changes in inflation dynamics. However, as shown in Figure 1, in recent data the stock-bond covariance calculated using real bond prices tracks the nominal counterpart almost exactly, posing an additional hurdle to such inflation-based explanations.

Naturally, surprises to realized inflation provide a further source of time variation in the stock-bond covariance. Indeed, it is likely that a full account of the evolution of the covariance over a longer time-span—such as the large and positive covariance in the 1980s—needs to account for inflation dynamics. In the main calibration of the model I assume away inflation dynamics. However, I demonstrate that allowing for time-varying inflation changes the level of the stock-bond covariance, while still maintaining the dependence on risk price dynamics that is the focus of the paper.

In other related work Campbell et al. (2017) study a term structure model with a constant price of risk and attribute the changing sign of the stock-bond covariance to the change in covariance between the nominal interest rate and the real economy. Campbell et al. (2018) focus on the interaction of preferences and changing inflation exposure of the real economy to demonstrate the importance of risk premia in accounting for the time-series of stock-bond return covariance.

Pflueger et al. (2018) construct a measure of aggregate risk appetite by comparing the relative valuations of high and low volatility stock portfolios. They document that this measure has strong explanatory power over the short interest rate and predicts investment. I show that their measure of relative valuations follows the high-frequency stock-bond covariance very closely in the recent data. I therefore interpret the relative valuation measure in Pflueger et al. (2018) as being driven by the same underlying phenomenon than the stock-bond covariance.

I organize the paper in three main sections. In the first section document a number empirical regularities regarding the stock-bond covariance in recent data. I show the stock-bond covariance corresponds to a "level" effect on the term structure of safe rates, can predict safe bond returns, relative returns of risky over safe bonds, returns of bond-like stocks, and account for safe share of corporate bond issuance. I also show that the stock-bond covariance calculated using local stock and bond prices in other developed economies demonstrates strikingly similar time series behavior.

In the second section I write down a term structure model that can account for the high-frequency variation the stock-bond covariance. I work with an exogenously specified price of risk process and derive recursively the term structures of risky and safe asset prices. I show that the model can

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fit the observed level and variation in the covariance (or beta) of the long bond. I also confirm that the model-implied stock-bond covariance is large and negative during times when the price of risk is high. Additionally, the model captures well other major asset price moments, such as the aggregate risk premium, and variation in expected returns.

In the third section I explore model-generated data. Because in the simulations I directly observe the price of risk and dividend growth rates I am able to evaluate the relative importance of these state variables with respect to market valuations, stock-bond covariance, and the term structure of interest rates.

Specifically, I demonstrate that in the calibrated model a two-factor "level" and "slope" decomposition of safe interest rates emerges. The simulated data reveals that the price of risk process has a strong impact on the level of interest rates. The time-varying dividend growth rate, in contrast, determines the slope of the term structure. Just like in the data, the level factor corresponds to the majority of yield curve variation.

The model presented here therefore highlights the first order importance of precautionary savings in determining safe interest rates. By emphasizing the quantitatively large effect of time-varying risk aversion on intertemporal substitution, the calibration underlines the role of precautionary savings in escaping the "macro-finance separation" of Tallarini (2000). A spike in risk aversion—everything else equal—changes the price of intertemporal substitution, hence the price of consumption and production.

2 Empirical Facts

In this section I describe the behavior of the stock-bond covariance and show how it relates to the level of safe and risky interest rates, the returns on safe and risky assets, risk-neutral moments of the Treasury return distribution, and holdings and issuance of fixed income assets.

For the majority of empirical facts I employ monthly data from 1973 to 2019. I choose the start date to reflect the availability of credit spreads, particularly the Gilchrist and Zakrajšek (2012) credit spread. A number of the regression estimates are presented separately for the sample from 1997 to 2019. The reason is twofold. Many of the data items, such as real bond prices in the US, holdings data, and issuance data have only become available recently. More importantly, this restricts to a time period where inflation has been under control.

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2.1 Stock-Bond Covariance

Figure 1 plots the stock-bond covariance from 1973 to 2020. I calculate the covariance between the return on the CRSP value-weighted portfolio, and the return on a 10-year zero coupon Treasury bond in a rolling 30-day window. I then average the daily calculated covariances to a monthly frequency. Zero-coupon bond prices are from the daily fitted yield curve constructed by Gürkaynak et al. (2007).

To put the recent data into historical context, I'm also including a longer time-series in Figure 2. Here I'm using monthly return data and the stock-bond covariance is calculated using a rolling window of 30 observations from 1880 to 2018. Figure 2 shows that the large negative covariance is mostly a recent phenomenon, though the 1960s and assorted shorter episodes before have also seen negative stock-bond covariance.

Perhaps surprisingly—and as already documented in prior work—the covariance between real bonds and the stock market is almost identical to the nominal bond covariance. In the US, Treasury Inflation Protected Securities (TIPS) have traded since 1996 and outside the most severe negative spikes, the covariance with the stock market of the real bonds has been nearly identical to that of nominal Treasuries, as shown on Figure 1.

A simple, though unlikely, explanation is that the Bureau of Labor Studies measured inflation that determines the TIPS coupon rate is a poor measure of true inflation, and in effect the TIPS payout is that of a nominal bond plus noise. A more plausible explanation is that in recent times inflation has has been under control and surprises in the inflation rate have been small. The impact of inflation shocks on bond returns can be mild if realized inflation close to expectations, or if inflation shocks command a small price of risk. In the baseline calibration of the model I work with a fixed zero inflation rate, though I also show how variation in inflation rates affects the value of the stock-bond covariance.

2.2 Term Structure of Safe Rates

Stock-bond covariance corresponds to a "level" effect on the term structure of interest rates. In Table 2 I regress the changes in the 1-, 3-, 5-, 10-, and 30-year zero coupon Treasury yields on the changes in the contemporaneous stock-bond covariance. All maturity rates tend to be lower when stock-bond covariance goes down, corresponding to the level factor of interest rates. This conclusion holds when I estimate the regression controlling for changes in stock return volatility measured over the same look-back window.

In order to summarize the impact on the entire yield curve I also estimate regressions with forward curve factors as left-hand-side variables. I start with the Gürkaynak et al. (2007) fitted yield

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curve data and decompose the daily 1 to 15 year forward rates by principal component analysis. Consistent with the literature (for instance, Cochrane and Piazzesi (2005)) I find that the first three components—traditionally labeled level, slope, and curvature—account for 99.96% of the variation in the forward rate curve. I again estimate the regressions in first differences, and controlling for changes in stock volatility.

The estimates in Table 3 underline that the stock-bond covariance has a level effect on the forward curve. Negative covariance times tend to see a higher slope factor, though that effect is not statistically significant. Stock-bond covariance also correlates with the curvature factor which also tends to be somewhat lower in times of negative covariance.

2.3 Credit Spreads

Corporate bond credit spreads show a strong correlation with the stock-bond covariance: during times when the covariance is negative, credit spreads tend to be high. In Table 4 I estimate regressions of ratings-based corporate bond spreads over Treasuries on the stock-bond covariance. I also include the GZ Spread constructed in Gilchrist and Zakrajšek (2012) and updated by the Federal Reserve Board[1]. The stock-bond covariance explains over 13% of the variation in the GZ spread and over 30% of the variation in the High Yield-Treasury spread. Again the regressions are estimated in first differences, and the conclusion holds true controlling for changes in the market volatility over the same look-back window. I illustrate this relationship in Figure 3. In the model I interpret times of negative stock-bond covariance as times when the price of risk is high—which in turn implies wide credit spreads.

2.4 Aggregate Return Predictability

Cochrane and Piazzesi (2005) find that risk premia across the term structure of Treasury rates is captured by a single variable that affects the term structure via the level factor. Any variable, then, that can explain movements in the level factor can potentially serve as a predictor of bond returns.

As shown in Table 5 Panels A and B the stock-bond covariance has some predictive power over longer maturity Treasury returns, particularly in the sample since 1997 when inflation has been tame. Negative covariance episodes predict poor Treasury returns going forward, consistent with the view that safe assets are particularly valued at those times. Panels C and D of the same Table find some evidence of aggregate stock return predictability, again concentrated in the sample since 1997. The stock-bond covariance predicts with a negative sign the excess market return at the

[1] https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/updating-the-recession-risk-and-the-excess-bond-premium-20161006.html

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five-year horizon, with an R^2 of 24%.

2.5 Relative Return Predictability

The stock-bond covariance does considerably better in prediction relative returns. Specifically, I show that it can predict returns on "bond-like" stocks and on credit-rating sorted bond portfolios. The estimates are in Tables 6, 7, and 8.

In Table 6 I show that the stock-bond covariance predicts with a negative sign the 12-month returns on bond portfolios that are long risky bonds and short Treasuries of equivalent maturity. The regressions reveal a substantial predictability in the relative returns, with R^2 over 10% for Baa-rated bonds in the recent sample. The predictive power of stock-bond covariance is not subsumed by other predictors such as the Cochrane and Piazzesi (2005) factor (constructed like in Hodrick and Tomunen (2018)) or the sentiment factor of Baker and Wurgler (2006).

Tables 7, and 8 document predictability in long-short portfolios that seek to capture "bond-like" stocks. The portfolios are constructed following Baker and Wurgler (2012). The seven portfolios are: *age*—long old firms, short young firms; *dbe*—long high dividend to book equity firms; *bm*—long high book to market firms; *ebe*–long high earnings to book equity firms; *efa*—long high external finance firms; *gs*—long high sales growth firms; *rvol*—long high volatility firms.

I find statistically significant return predictability in the expected direction for many of these portfolios at both the 12- and 60-month horizon. Older firms, high dividend firms, high earnings firms, and low volatility firms tend to underperform after episodes of large negative stock-bond covariance, consistent with the view that these assets are highly valued during such periods. Like with the bond predictability returns the conclusions are robust to including known predictors such as the Cochrane and Piazzesi (2005) factor or Baker and Wurgler (2006) sentiment factor.

2.6 Risk Neutral Distribution of Safe Returns

With the availability of traded options on Treasury futures it is possible to construct forward-looking measures of the risk-neutral Treasury return distribution. In this section I show that the stock-bond covariance is more negative when implied volatility is high, and when the probability of a jump in Treasury prices (a flight-to-quality episode) is high.

Using Treasury options data from the CME Group, I follow Choi et al. (2017) and calculate the

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10-year Treasury implied volatility as:

$$IV_t = \sqrt{\frac{2e^{rT}}{T}\left(\sum_{K_i=0}^{F_{t,T}} \frac{P_{t,T}(K_i)}{K_i^2}\Delta K + \sum_{K_i=F_{t,T}}^{\infty} \frac{C_{t,T}(K_i)}{K_i^2}\Delta K\right)} \tag{1}$$

where $C_{t,T}(K)$ and $P_{t,T}(K)$ are the time t prices of calls and puts with strike K maturing at time T, r is the continuously compounded risk-free rate, and F_t is the time t price of the underlying futures contract.

I follow Bollerslev and Todorov (2011) to estimate the probability of large jumps in the underlying future from out-of-the-money option prices. Specifically, I calculate:

$$LT_t(k) = \frac{e^{rT}C_{t,T}(K)}{(T-t)F_t} \quad \text{and} \quad RT_t(k) = \frac{e^{rT}P_{t,T}(K)}{(T-t)F_t} \tag{2}$$

where $k = \frac{F_t}{K}$ is the moneyness of the underlying option and the remaining notation is as before. $LT_t(k)$ measures the time t risk-neutral probability of an upward jump to price $k \times F_t$ or higher of the underlying futures contract. Similarly, $RT_t(k)$ measures the probability of a downward jump to price $k \times F_t$ or lower of the underlying futures contract, corresponding to an increase in the interest rate.

As shown in Table 10, implied volatility of the 10-year bond price coincides with negative covariance episodes. Intriguingly, a high risk-neutral probability of a jump in bond prices (meaning a flight-to-quality episode) is associated with larger negative stock-bond covariance. In contrast, a high probability of a drop in bond prices is associated with a positive covariance.

2.7 Issuance

As documented above, negative stock-bond covariance episodes see a wider spread between prices of safe and risky fixed income assets. It is therefore reasonable to expect that potential issuers of safe corporate bonds would find it an opportune time to increase issuance. This is precisely what I find. As shown in Table 11, negative stock-bond covariance episodes see a larger share of safe asset issuance over total corporate issuance. Specifically, both the share of investment grade issuance and the share of issuance with a rating of A or better are increasing during negative covariance episodes. Similarly, the share of financial sector investment grade issuance over GDP is higher when the covariance is negative.

Combined with the previously discussed result on bond return predictability, these facts offer a new way to interpret the results in Greenwood and Hanson (2013). These authors find that a high share of non investment grade issuance in the corporate bond market predicts poor corporate bond returns going forward. As shown above, negative stock-bond covariance times see an increase in

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the wedge between safe and risky bond prices—inducing more issuance from high grade issuers. Going forward, on average prices tend to converge as the price of risk returns to normal levels. As a consequence, the non investment grade issuance share negatively predicts bond returns.

2.8 Holdings

Stock-bond covariance can also account for time-series variation in the sectoral holdings of safe assets. I construct quarterly holdings of Treasury assets based on data from *Financial Accounts of the United States* (formerly the *Flow of Funds.*) As shown in Table 12, times of negative covariance broker-dealers and money market funds tend to increase the holdings of Treasuries. I interpret these findings as evidence in high demand during bad times for safe collateral by the shadow banking system, as modeled in Moreira and Savov (2017).

2.9 International Evidence

Evidence from other markets reveals that the time varying stock-bond correlation is a feature in many developed economies. What is more, the local market stock-bond correlations follow a strong factor structure—times of negative covariance occur at the same time in all developed markets. I interpret this finding as evidence of substantial risk-sharing across global markets, as suggested by Brandt et al. (2006).

For instance, consider the data from U.S. and Germany. The U.S. and German stock markets tend to move in closely together with correlation of daily returns of .54. The respective bond movements show slightly weaker co-movement: the correlation in the daily data is .41. The estimated respective local stock-bond covariance processes, however, have a correlation of .83 in the time-series.

I show the international stock-bond covariances in Figure 4. Here I calculate the rolling stock-bond covariance with local data from the U.S., Germany, Great Britain, Japan, and Spain. As the figure shows, all these countries experienced a negative stock-bond covariance episode during the Global Financial Crisis. With the exception of Japan, all the countries also saw a strong negative covariance episode in the early 2000s.

Let me make two more observations. Japan was the first to witness negative covariance in the early 1990s when local interest rates first hit zero and inflation crossed into negative territory. Spain saw the local stock-bond covariance wander into large positive territory precisely when its bonds became risky during the Global Financial Crisis.

In Table 9 I demonstrate FX return predictability with the U.S. stock-bond covariance. Times of negative stock-bond covariance in the U.S. see positive excess returns on foreign currencies going forward. This evidence is consistent with the view that negative stock-bond covariance periods see

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increases in demand for USD. This predictability is particularly strong in the sample 1996 when inflation innovations have been tame.

2.10 Pandemic Sample

Market behavior during the recent global pandemic illustrates the striking time variation in stock-bond covariance. In Figure 5 I plot the stock-bond covariance since the beginning of 2020. The calculation is slightly different than the main variable used in the rest of the paper. I use the prices of the SPDR SP500 ETF (ticker: SPY) and the iShares 7-10 year Treasury ETF (ticker:IEF) to calculate returns in 15-minute intervals, and calculate the stock-bond covariance over a 2-day lookback window.

As the Figure shows, the initial drop in market values in late February did not see a spike in the stock-bond covariance, despite increased volatility as measured by VIX. The first three weeks of March, in contrast, saw unprecedented levels of stock-bond covariance with the two-day calculation using intraday returns reaching values of -36, more than twice the highest levels of the same quantity during the 2008 financial crisis. This underlines the importance of discount rate volatility at the height of the market turmoil in spring 2020. In line with the return predictability documented in this section, the subsequent stock market returns from April onwards have been substantial.

3 Model

The goal of the theory section to construct a tractable model that delivers a high-frequency variation in the stock-bond covariance. To this end, I follow the approach in Lettau and Wachter (2007) and assume an exogenously specified process for the price of risk. The calibrated model uses parameters that can match the aggregate equity risk premium to demonstrate that it can also deliver the time variation in the stock-bond covariance.

I specify that the state variable x_t that governs the price of risk follows a Cox, Ingersoll Jr. and Ross (1985) (CIR) process. The CIR process features time-varying volatility: in this formulation the price of risk is volatile precisely when it is high. It therefore provides a convenient way to impose time-varying volatility of the aggregate risk premium. I also specify that the volatility of the aggregate dividend process is proportional to $\sqrt{x_t}$. As a result of this modeling choice, both the equity risk premium and the precautionary savings component of the risk-free rate are linear in the state variable x_t, allowing me to derive prices of risky and safe assets in closed form.

I do not specify the source of this variation in the price of risk—it could stem from time-varying disaster risk, habits, behavioral effects, and so on. All modern asset pricing models feature some source of time variation in the price of risk.

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Let me set up the model. The log changes in the aggregate endowment process follow

$$\ln\left(\frac{D_{t+1}}{D_t}\right) = \Delta d_{t+1} = g + z_t + \sqrt{x_t}\sigma_d\epsilon_{t+1} - \frac{1}{2}\sigma_d^2 x_t, \tag{3}$$

while the log stochastic discount factor (SDF) is given by

$$m_{t,t+1} = a - \rho(g + z_t) - \gamma\sqrt{x_t}\sigma_c\epsilon_{t+1}. \tag{4}$$

These two equations contain the two state variables of the economy: the price of risk, $\sqrt{x_t}$, and the aggregate dividend growth rate, z_t. I have assumed an SDF that separates out the preference parameters governing risk aversion and intertemporal elasticity of substitution.

As already mentioned, the process x_t evolves according to a CIR process by which its volatility is proportional to the square root of the current value

$$x_{t+1} = (1 - \phi_x)\bar{x} + \phi_x x_t + \sqrt{x_t}\sigma_\eta\eta_{t+1}, \tag{5}$$

while the aggregate dividend growth rate evolves according to an AR(1) process

$$z_{t+1} = \phi_z z_t + \sigma_\xi\xi_{t+1} \tag{6}$$

with constant volatility. Note that the only shock that is directly priced is the dividend growth shock ϵ. With this setup I can find closed-form expressions for asset prices using recursive substitution, like in Lettau and Wachter (2007).

Finally, let the price level Π_t evolve according to

$$\ln\left(\frac{\Pi_{t+1}}{\Pi_t}\right) = \Delta\pi_{t+1} = i + \theta z_t \tag{7}$$

where the parameter θ governs the dependence of the price level on the growth rate of the economy.

3.1 Bond Prices

Let me start by deriving the term structure of interest rates. At time t the price of a zero-coupon bond with maturity n periods from now—denoted $P^f_{n,t}$—has to satisfy:

$$P^f_{n,t} = E_t\left[\exp\{m_{t,t+1}\}\exp\{-\Delta\pi_{t+1}\}P^f_{n-1,t+1}\right] \tag{8}$$

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Let me guess and verify that bond prices are affine in the state variables. The pricing equation then reads

$$\begin{aligned}
&\exp\left\{A^f_{(n)} + B^f_{(n)}x_t + C^f_{(n)}z_t\right\} = \\
&= \mathrm{E}\left[\exp\left\{a - \rho(g+z_t) - \gamma\sqrt{x_t}\sigma_c\epsilon_{t+1}\right\}\exp\{-i-\theta z_t\}\right. \\
&\left.\exp\left\{A^f_{(n-1)} + B^f_{(n-1)}x_{t+1} + C^f_{(n-1)}z_{t+1}\right\}\right] \qquad (9)\\
\implies A^f_{(n)} &= a - \rho g + A^f_{(n-1)} - i + B^f_{(n-1)}(1-\phi_x)\bar{x} + \frac{1}{2}C^f_{(n-1)}C^f_{(n-1)}\sigma^2_\xi \qquad (10)\\
\implies B^f_{(n)} &= B^f_{(n-1)}\phi_x + \frac{1}{2}B^f_{(n-1)}B^f_{(n-1)}\sigma^2_\eta + \frac{1}{2}\gamma^2\sigma^2_c \qquad (11)\\
\implies C^f_{(n)} &= C^f_{(n-1)}\phi_z - \rho - \theta \qquad (12)
\end{aligned}$$

The boundary condition from a bond about to mature yields in $A^f_{(0)} = B^f_{(0)} = C^f_{(0)} = 0$. Any other maturity safe bond price can be found by applying the above recursions. In Figure 10 I plot the values for the coefficients A^f, B^f, and C^f at different maturities.

3.2 Stock Prices

In order to solve for stock prices let's define the price dividend ratio of a maturity n dividend strip as

$$F_{n,t} = \frac{P_{n,t}}{D_t} = \exp\left\{A_{(n)} + B_{(n)}x_t + C_{(n)}z_t\right\}. \qquad (13)$$

Dividend strip prices have to satisfy the recursive pricing equation

$$P_{n,t} = E_t\left[\exp\{m_{t,t+1}\}\frac{D_{t+1}}{D_t}\exp\{-\Delta\pi_{t+1}\}P_{n-1,t+1}\right]. \qquad (14)$$

Proceeding again by guess and verify, we can find the price dividend ratio of the cash-flow

$$\Delta d_{t+1} = g + z_t + \sqrt{x_t}\sigma_d\epsilon_{t+1} - \frac{1}{2}\sigma^2_d x_t \qquad (15)$$

by recursively solving for the parameters in the following pricing equation

$$\begin{aligned}
\exp\left\{A_{(n)} + B_{(n)}x_t + C_{(n)}z_t\right\} = \mathrm{E}\Bigg[&\exp\left\{a - \rho(g+z_t) - \gamma\sqrt{x_t}\sigma_c\epsilon_{t+1}\right\}\exp\left\{g + z_t + \sqrt{x_t}\sigma_d\epsilon_{t+1} - \frac{1}{2}\sigma^2_d x_t\right\}\\
&\exp\{-i-\theta z_t\}\exp\left\{A_{(n-1)} + B_{(n-1)}x_{t+1} + C_{(n-1)}z_{t+1}\right\}\Bigg]\\
= \mathrm{E}\Big[&\exp\left\{a - \rho(g+z_t) + \gamma\sqrt{x_t}\sigma_c\epsilon_{t+1} + g + z_t + \sqrt{x_t}\sigma_d\epsilon_{t+1} - \frac{1}{2}\sigma^2_d x_t\right.\\
&+A_{(n-1)} + B_{(n-1)}((1-\phi_x)\bar{x} + \phi_x x_t + \sqrt{x_t}\sigma_\eta\eta_{t+1})\\
&\left.+C_{(n-1)}(\phi_z z_t + \sigma_\xi\xi_{t+1})\right\}\Big]. \qquad (16)
\end{aligned}$$

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Matching coefficients results in the following recursive relationships

$$\implies A_{(n)} = a - \rho g + g - i + A_{(n-1)} + B_{(n-1)}(1-\phi_x)\bar{x} + \frac{1}{2}C_{(n-1)}^2\sigma_\xi^2 \tag{17}$$

$$\implies B_{(n)} = B_{(n-1)}\phi_x - \gamma\sigma_c\sigma_d + \frac{1}{2}B_{(n-1)}^2\sigma_\eta^2 + \frac{1}{2}\gamma^2\sigma_c^2 \tag{18}$$

$$\implies C_{(n)} = C_{(n-1)}\phi_z - \rho + 1 - \theta. \tag{19}$$

Like before, boundary conditions of an equity strip about to mature imply $A_{(0)} = B_{(0)} = C_{(0)} = 0$. In Figure 10 I plot the three coefficients as a function of dividend maturity.

The aggregate price dividend ratio is just the sum of the price dividend ratios of all the constituent dividend strips.

$$\frac{P_t^m}{D_t} = \sum_{n=1}^{\infty}\frac{P_{n,t}}{D_t} = \sum_{n=1}^{\infty}\exp\left\{A_{(n)} + B_{(n)}x_t + C_{(n)}z_t\right\} \tag{20}$$

With the price-dividend ratios in hand the realized market returns are calculated according to

$$R_{t,t+1} = \frac{\frac{P_{t+1}^m}{D_{t+1}} + 1}{\frac{P_t^m}{D_t}}\frac{D_{t+1}}{D_t}. \tag{21}$$

3.3 Calibration of the Model

I calibrate the model to match the observed level and volatility in both the 10-year bond beta and covariance with respect to stock market returns.

Recall that there is only one shock in the economy that is directly priced: the consumption growth innovation ϵ. The compensation for this risk is determined by the quantity $\gamma\sigma_c\sqrt{x_t}$. I choose $\gamma = 3$, $\sigma_c = 1.3\%$, and $\bar{x} = 70$ meaning that the average Sharpe ratio of the ϵ shocks is just above .3:

$$\text{SR} = \gamma\sqrt{\bar{x}}\sigma_c = 3 \times \sqrt{60} \times .013 = .302 \tag{22}$$

The time variation in stock-bond covariance depends on the volatility of the price of risk process. I pick $\sigma_\eta = 2$ and $\phi_x = .93$. The persistence of the price of risk process is close to the value of .87 used in Lettau and Wachter (2007).

The dividend growth shocks have twice the volatility than consumption growth shocks with $\sigma_d = 2.6\%$. Note that the quantities σ_c and σ_d do not have the exact same interpretation than usual because they always appear jointly with the price of risk $\sqrt{x_t}$. The resulting average dividend growth volatility is $\sigma_d\sqrt{60} = 20\%$ which is again somewhat higher than the corresponding quantity Lettau and Wachter (2007).

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Description	Variable	Value
Time Discount	a	-0.041
Risk Aversion	γ	3.000
One over IES	ρ	1.100
Consumption Growth Rate	g	0.020
Consumption Volatility	σ_c	0.013
Dividend Volatility	σ_d	0.026
Average Price of Risk Squared	$\bar{x}$	60.000
Price of Risk Squared Volatility	σ_η	2.000
Price of Risk Squared Persistence	ϕ_x	0.930
Dividend Growth Rate Volatility	σ_ξ	0.002
Dividend Growth Rate Shock Persistence	ϕ_z	0.800
Growth sensitivity of inflation rate	θ	0.000
Inflation rate	i	0.000

Table 1: Model Parameters. Preference parameters are unitless. All other parameters reported in annualized terms. The model is simulated daily.

The persistence of the time varying component of the dividend growth rate shocks is .8, while it's the volatility is .24%. The persistence is somewhat lower than the corresponding value in Lettau and Wachter (2007), while the volatility is exactly the same.

The parameter ρ corresponds to one over the intertemporal elasticity of substitution (IES). I set $\rho = 1.1$, meaning IES < 1. This choice provides a source of positive stock-bond covariance in a zero inflation setting as IES is less than 1, and also tapers the stock-bond covariance stemming from innovations in the dividend growth rate (the roles of IES and risk aversion in determining stock-bond covariance are discussed in Barsky (1989)). Finally, I set the time discount parameter $a = \ln(.96)$.

In the benchmark calibration I set the rate i and growth sensitivity θ of inflation to zero.

4 Stock-Bond Covariance in the Model

4.1 Simulation Results

In order to study the model implied stock-bond covariance I draw 1,000,000 trading days of model shocks ϵ, η, and ξ and calculate asset prices according to the closed form solutions in Section 3 under the parameter values in Table 1.

The model matches well the principal asset pricing moments from the 1997-2019 sample. In Table 13 I show the equity premium, Sharpe ratio, the instantaneous risk-free rate, the precautionary

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savings component, and the 10-year yield under the calibration.

The average stock market rigsk premium under the calibration is 6.4%, with annualized Sharpe ratio of .29. The market risk premium shows substantial variation: its standard deviation is comparable to its mean. The average risk-free rate is 1.4% with the precautionary savings demand contributing an average of −4.4%, underlining the first order importance of risk compensation in determining the risk-free rate. The average ten year yield in the model is 1.2%.

The average monthly excess return in the model is .731 compared to .661 in the data while the respective monthly volatilities are 6.0% and 4.4%. In words, the model matches well the risk premium but somewhat overstates average return volatility. Similarly, the model overstates the volatility of the 10-year bond return at 3.5% relative to the empirical counterpart of 2.6%. That the model overstates the volatility of stock and bond returns stems in part from occasional very high price of risk episodes that are a result of the CIR process that governs the aggregate price of risk.

The model is able to deliver 10y bond-stock covariance and stock beta of the 10y bond that match well the empirical counterparts. The average stock-bond covariance is −.192 in the data, compared to −.48 in the data. The the model-implied standard deviation of stock-bond covariance is .478, compared to the empirical counterpart of 1.0. However, the model-implied standard deviation matches well the empirical stock-real bond covariance at .528.

Similarly, the average stock beta of the nominal 10y bond is −.11 in the data, and −.034 in the model; while the respective standard deviations are .263 and .125. Again the real bond beta is very close to the model values: average real bond beta is −.08 with standard deviation .15.

Just as is the case empirically, the stock-bond covariance is left skewed, while the bond beta is right skewed. In the model this feature stems from the fact that market return volatility tends to be high precisely when the price of risk is high. I show the simulated distribution of 10-year Treasury beta and the stock bond covariance in Figure 6.

Figure 7 shows that long bond betas tend to be more negative precisely when the price of risk is high. In this Figure I'm sorting the simulated sample into deciles based on the current level of the price of risk and showing the probability that the 30-day backwards-looking rolling beta is negative.

Finally, Table 14 shows that the stock-bond covariance has similar persistence than in the data. In the data last month's stock-bond covariance explains 50% of the variation in the current covariance, compared to 23% in the model. The 6- and 12-month lagged stock-bond covariance predict current covariance with coefficients of .12 and .10 in the model while in the data these coefficients are .24 and .11, respectively.

The main calibration seeks to demonstrate that the time variation in the stock-bond covariance

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obtains without any inflation dynamics—both the level and growth rate dependence of inflation are set to zero. This choice is motivated by the observation that the stock-bond covariance with real bonds closely follows the covariance with nominal bonds, as shown in Figure 1.

In the bottom two rows of Table 13 I show the stock-bond covariance under a calibration when the inflation rate is set to 2%, and the parameter θ that governs inflation sensitivity to growth rate news is 1. In this calibration the stock-bond covariance behaves in the same manner with respect to risk price dynamics, however the level of the covariance is elevated, matching the empirical evidence from the high inflation volatility period in the 1970s and 1980s.

In the model calibration with inflation innovations the covariance between equity risk premium and real yields is still negative for the same reason as in the benchmark model—an increase in the price of risk brings along a larger precautionary savings term. However, the non-zero correlation between growth shocks and inflation changes the level of covariance between equity and nominal bond returns.[2]

4.2 Stock-Bond Covariance and State Variables

The simulated data allows me to study the behavior of stock-bond covariance as a function of the state variables. In Table 15 I regress the model-calculated backwards-looking stock-bond covariance on the state variables of the model. As the Table reveals, the stock-bond covariance is increasing in the price dividend ratio, and decreasing in the price of risk. This is expected: because the price of risk follows a CIR process, the price of risk is volatile precisely when it is high.

As described above, high volatility of the price of risk process contributes to a negative stock-bond covariance. The high level of the price of risk, then, corresponds to times when a lot of stock-bond covariance stems from changes to the price of risk. Similarly, when the price of risk is high the price-dividend ratio is low on account of the elevated equity risk premium. Correspondingly, the price-dividend ratio is negatively correlated with the stock-bond covariance. In contrast, the aggregate dividend growth rate has no explanatory power over the variation in the bond beta. Overall, the price of risk can explain 11% of the variation in the stock-bond covariance.

4.3 Term Structure of Interest Rates

While the model is designed and calibrated to match the data with respect to the stock-bond covariance, it captures well key characteristics of the yield curve.

[2]There is other empirical evidence for this view. The calibrated VAR in Gonçalves (Forthcoming) implies that the covariance between the equity risk premium and nominal yields is negative throughout the postwar sample. (see Table IA.5 in that paper.)

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Specifically, I show that a two factor structure of safe interest rates emerges in the model, closely reflecting the empirical evidence. To demonstrate this I use the calibrated model to calculate the yield curve for maturities from 1 to 20 years and apply the same principal component decomposition that I used in Section 2.

As shown in Figure 8, the safe asset factor loadings display a striking "level" and "slope" factor. The first principal component—level—accounts for 98% of the variation of the yield curve, compared to 95% in the data. The second factor—slope—explains almost all of the residual variance in both the model and the data.

Because I observe the price of risk and dividend growth rate in the simulations I can directly estimate how these two state variables affect the term structure. To summarize the state variables' impact on the whole yield curve I estimate regressions with the yield curve factors on the left hand side.

The results are reported in Table 16. The price of risk process is responsible for the majority of changes to the level factor of interest rates. In contrast, the time-varying dividend growth rate is mostly responsible for the variation in the slope factor. The stock-bond covariance—the empirical proxy for the price of risk—explains over 9% of the variation in the level factor. The stock-bond covariance has a weaker explanatory power over the slope factor. Overall, these results are exactly in line with the empirics presented in Section 2. The stock-bond covariance has a positive effect on the level factor, but a negative effect on the slope factor.

In Figure 8 I show the yield curve factor loadings in the model and in the data. In Figure 9 is show the average yield curve by state variable tercile. Compared to the price of risk, the effect of the time-varying dividend growth rate decays faster, reflecting the lower persistence under the calibration parameters shown in Table 1.

4.4 Return Predictability

The model also delivers return predictability in equity prices. As shown in Table 17, the price-dividend ratio is a good predictor of 60-month ahead excess stock returns—the price dividend ratio explains 14% of the return variation. Just like in the data, the realized stock-bond covariance can predict stock returns in the model with R^2 of 2%. The model features no predictability in excess bond returns. This is because the growth rate and price of risk shocks are themselves not directly priced by model assumption.

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4.5 The Leverage Effect

In the theory section I have assumed a representative firm that actively manages its liabilities to maintain a constant leverage ratio. In reality, market leverage of individual firms, and of the aggregate market changes considerably over time.

Choi et al. (2019) point out that such variation in the capital structure introduces time variation in the stock-bond covariance even if the underlying assets have zero covariance with interest rates. Empirically, Choi et al. (2019) estimate firm-level asset returns by directly measuring returns of equity, bonds, and loans. They demonstrate that the asset-bond covariance is materially different from the usual equity-based calculation.

In the model presented here, the relationship between equity and asset beta depends on the riskiness of the debt. Consider an increase in the price of risk. A firm with Aaa-rated debt would likely see a muted impact on its asset value as the prices of its bonds would increase because of the precautionary savings effect and counter the drop in the value of stocks. In contrast, a firm with non-investment grade debt would likely see firm value drop as the risk premium component of the bond price outweighs the contemporaneous drop in safe rates. The *asset-bond* covariance can therefore be substantially different than the stock-bond covariance. In particular, for firms with safe debt the asset-bond covariance can be higher than the stock-bond covariance.

To illustrate this effect empirically I perform the following aggregate analysis. In each quarter from 1990 to 2019 I calculate the book leverage of firms in the Compustat sample. I then calculate asset returns by assuming all outstanding debt is rated either Aaa, Baa, or High-Yield, and has the maturity of ten years. I am then able to calculate hypothetical asset returns for each level of bond riskiness.

The results are shown in Figure 11. Under the extreme assumption that all debt is Aaa-rated the aggregate asset-bond covariance can occasionally flip sign relative to the stock-bond covariance—see the evidence from 2009 in the bottom panel. In the more realistic cases of Baa or high-yield debt, however, the gap between asset- and equity-based measures is more muted. Importantly, the *correlation* between the asset- and stock-based covariance measures is .87, .69, and .60 for the High-Yield, Baa, and Aaa-based measures, respectively.

5 Literature

As discussed in the Introduction, a number of papers have studied the stock-bond covariance. Closest is recent work in Kozak (2015) proposing an explanation of the time variation in stock-bond covariance using a purely real, production-based model. In this model the time variation in the stock-bond covariance arises from the changing relative share of two production processes in the

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economy: a relatively safe, bond-like process and a relatively risky, stock-like process. In contrast, in my model the risk exposures of assets are constant, and only the relative share of price of risk and dividend growth shocks is changing.

Methodologically the work here is closest to Bekaert and Grenadier (1999) who jointly study the pricing of stocks and bonds in affine economies. They report the stock-bond correlation in the various economies they study, though without addressing the time variation (the recent negative stock-bond covariance period was only emerging at the time of their writing.) Lettau and Wachter (2007) and Lettau and Wachter (2011) use the affine framework to study pricing of equity risk across maturity as well as the term structure of safe rates.

Barsky (1989) studies the role of risk aversion and intertemporal elasticity of substitution in contributing to the comovement of stock and bond prices in general equilibrium.

Campbell et al. (2017) attribute the stock-bond covariance dynamics to a change in the covariance between nominal rates and the real economy. Campbell et al. (2018) explore the implications of a changing covariance between inflation and output using a habits based model of investor preferences. Bilal (2017) shows that the the possibility of the zero lower bound binding can change the stock-bond covariance in a New Keynesian model.

As already discussed, Choi et al. (2019) demonstrate that changes in the aggregate leverage of the corporate sector have a material effect on the observed stock-bond covariance.

Also discussed in detail above, Baker and Wurgler (2012) use the cross-section of stock returns to demonstrate that the returns of bond-like stocks are more exposed to bond risk factors. They discuss multiple potential underlying causes, such as cash-flow risk, time-varying discount rates, and investor sentiment.

David and Veronesi (2013) build a learning-based model in which investors seek to understand the joint dynamics of earnings growth, consumption, and inflation. Baele et al. (2010) empirically study the various macroeconomic and financial determinants of the stock-bond covariance. Baele et al. (2018) identify flight-to-quality days in a panel of 23 countries. Xu (2017) studies the correlations between international stock returns, and between international bond returns. She establishes that stock co-movements are counter-cyclical, while bond co-movements are procyclical and attributes this feature to a global risk aversion factor.

Du (2017) goes beyond the representative agent framework and studies the stock-bond covariance in a model with heterogeneous beliefs. In his model heterogeneity in investor beliefs regarding growth and inflation rates delivers a time-varying stock-bond covariance without any effect stemming from risk preferences.

Greenwood and Hanson (2013) study bond returns as a function of market sentiment at issuance

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time while López-Salido et al. (2017) study the impact of credit market sentiment on economic activity going forward.

Pflueger et al. (2018) show that the relative valuations of volatile stocks have a strong relationship with the real interest rate. They further demonstrate that positive shocks to the relative valuations of volatile stocks lead to a boom in investment, output, and employment. Their main variable of interest, the difference between average book-to-market ratios of high and low volatility stocks (labeled PSV) is in the recent data strongly correlated (.48) with the stock-bond covariance. This is consistent with the interpretation provided in this paper that episodes of high price of risk see a more negative stock-bond covariance. Pflueger et al. (2018) attribute the variation in PSV to (perhaps behavioral) time variation in investor risk appetite. In this paper the negative stock-bond covariance episodes reveal a high price of risk without appealing to any given structural model: the changes in the price of risk could be driven by disaster risk, habits, behavioral effects, and so on.

The stock-bond covariance is likewise positively correlated (.58) with the Bond Market's q measure constructed in Philippon (2009). I show the time series of PSV and the Bond Market's q in Figure 12.

6 Conclusion

This paper studies the stock-bond covariance. I show that a high-frequency variation in the stock-bond covariance arises in a model with time-varying volatility in the price of risk process. The model presented here can be solved in closed form and variation in the stock-bond covariance arises through a purely real channel. Empirically, I show that the stock-bond covariance co-moves with aggregate credit spreads, and can predict excess returns of stock-like bonds, excess returns of risky over safe bonds, as well as issuance and sectoral holdings of safe assets.

All modern asset pricing models feature time variation in the price of risk. For analytical convenience, these models often abstract from the impact of risk attitudes on safe interest rates. For instance, Campbell and Cochrane (1999) makes the explicit decision to equate the precautionary savings term of the risk free rate with the intertemporal elasticity of substitution term to ensure a constant rate. But the risk dynamics from these models can still be used to study risk-free rates. In particular, I have shown that a price of risk process calibrated with the equity market in mind can match the empirical stock-bond covariance in the recent data, without any contribution from inflation dynamics. Therefore, the time variation in stock-bond covariance can serve as a another asset pricing moment that helps to discipline dynamics of risk prices.

Under the calibration in this paper, the time variation in risk compensation has a first order importance on the safe yield curve. The simulated model exhibits a factor structure closely reflecting the empirical counterpart. The first factor ("level"), responsible for the majority of the term

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structure variation, is mostly driven by the price of risk process, thus emphasizing the importance of risk prices with respect to understanding the term structure of safe interest rates.

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7 Tables

Panel A.

	D.yield 1y	D.yield 3y	D.yield 5y	D.yield 10y	D.yield 30y
D.Cov(Tr 10y, St.)	0.0948***	0.0750**	0.0638**	0.0586**	0.0627***
	(3.53)	(3.28)	(3.08)	(3.13)	(3.78)
Constant	-0.0103	-0.0106	-0.0105	-0.00991	-0.0215*
	(-0.53)	(-0.65)	(-0.71)	(-0.76)	(-2.06)
Observations	569	569	569	569	415
R^2	0.021	0.018	0.016	0.017	0.034

Panel B.

	D.yield 1y	D.yield 3y	D.yield 5y	D.yield 10y	D.yield 30y
D.Cov(Tr 10y, St.)	0.0905**	0.0630*	0.0522*	0.0529*	0.0616**
	(3.03)	(2.48)	(2.26)	(2.53)	(3.03)
D.Vol(St.)	-0.121	-0.333	-0.324	-0.158	-0.0225
	(-0.31)	(-1.01)	(-1.09)	(-0.59)	(-0.09)
Constant	-0.0103	-0.0106	-0.0104	-0.00988	-0.0215*
	(-0.53)	(-0.65)	(-0.71)	(-0.75)	(-2.06)
Observations	569	569	569	569	415
R^2	0.021	0.020	0.018	0.018	0.034

Table 2: Treasury Yield Curve and Stock-Bond Covariance. Stock-bond covariance is calculated using CRSP value-weighted aggregate return and the return on 10-year constant-maturity Treasury. The look-back window is 30 days and the data is averaged monthly. Vol(St.) refers to the market volatility over the same look-back window. Yields measured from the fitted yield curve in Gürkaynak et al. (2007). Newey-West standard errors with 12 lags Monthly data 1973-2020, except 30-year yield which starts in 1985.

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Panel A.

	D.Level	D.Slope	D.Curvature
D.Cov(Tr 10y, St.)	0.0857***	-0.0115	0.0172*
	(3.46)	(-1.04)	(2.06)
Constant	-0.0125	-0.000192	0.000492
	(-0.75)	(-0.03)	(0.16)
Observations	568	568	568
R^2	0.021	0.002	0.009

Panel B.

	D.Level	D.Slope	D.Curvature
D.Cov(Tr 10y, St.)	0.0828**	-0.0204	0.0181
	(2.99)	(-1.64)	(1.92)
D.Vol(St.)	-0.0814	-0.247	0.0244
	(-0.23)	(-1.61)	(0.21)
Constant	-0.0125	-0.000115	0.000484
	(-0.74)	(-0.02)	(0.15)
Observations	568	568	568
R^2	0.021	0.007	0.009

Table 3: Treasury Forward Curve Factors and Stock-Bond Covariance. Forward curve factors estimated using principal component analysis from the fitted daily yield curve in Gürkaynak et al. (2007). Stock-bond covariance is calculated using CRSP value-weighted aggregate return and the return on 10-year constant-maturity Treasury. The look-back window is 30 days and the data is averaged monthly. Vol(St.) refers to the market volatility over the same look-back window. Monthly data 1973-2020.

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Panel A.

	D.Aaa-Tr	D.Baa-Tr	D.HY-Tr	D.Baa-Aaa	D.GZ Spread	D.EBP
D.Cov(Tr 10y, St.)	-0.0466***	-0.0888***	-0.482***	-0.0422***	-0.121***	-0.0915***
	(-6.22)	(-8.24)	(-12.51)	(-6.20)	(-9.70)	(-5.73)
Constant	0.00170	0.00240	0.00711	0.000705	0.00345	0.000858
	(0.34)	(0.27)	(0.15)	(0.12)	(0.33)	(0.11)
Observations	569	569	282	569	566	566
R^2	0.063	0.100	0.322	0.058	0.135	0.060

Panel B.

	D.Aaa-Tr	D.Baa-Tr	D.HY-Tr	D.Baa-Aaa	D.GZ Spread	D.EBP
D.Cov(Tr 10y, St.)	-0.0245**	-0.0511***	-0.125*	-0.0266***	-0.0636***	-0.0676***
	(-3.02)	(-4.44)	(-2.41)	(-3.57)	(-5.08)	(-3.87)
D.Vol(St.)	0.616***	1.049***	5.843***	0.433***	1.769***	0.742***
	(5.94)	(6.93)	(8.80)	(4.37)	(11.33)	(3.60)
Constant	0.00156	0.00216	0.00578	0.000606	0.00228	0.000367
	(0.32)	(0.26)	(0.14)	(0.11)	(0.25)	(0.05)
Observations	569	569	282	569	566	566
R^2	0.119	0.171	0.449	0.089	0.290	0.081

Table 4: Corporate Spreads and Stock-Bond Covariance. HY refers to High-Yield bonds. GZ refers to the Gilchrist and Zakrajšek (2012) corporate spread. Aaa and Baa bond spread data from Moody's, HY from Bank of America. Monthly data 1973-2020, except HY which is available from 1997.

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Panel A. Excess Treasury Returns.

	5y 12m ER	10y 12m ER	20y 12m ER	30y 12m ER
Cov(Tr 10y, St.)	-0.00161	-0.00375	0.00555	0.0181
	(-0.28)	(-0.35)	(0.28)	(0.60)
Constant	0.0214**	0.0331**	0.0426	0.0481
	(3.15)	(2.61)	(1.82)	(1.38)
Observations	557	557	557	557
R^2	0.001	0.001	0.001	0.003

Panel B. Excess Treasury Returns Since 1997.

	5y 12m ER	10y 12m ER	20y 12m ER	30y 12m ER
Cov(Tr 10y, St.)	-0.00317	-0.00245	0.0160	0.0444*
	(-0.66)	(-0.28)	(1.08)	(1.99)
Constant	0.0231***	0.0428***	0.0698***	0.0937**
	(3.33)	(3.41)	(3.32)	(2.99)
Observations	257	257	257	257
R^2	0.007	0.001	0.016	0.053

Panel C. Excess Stock Returns.

	ER 12m	ER 24m	ER 36m	ER 60m
Cov(Tr 10y, St.)	0.0215	0.0237	0.0321	0.0478
	(1.43)	(0.88)	(0.86)	(0.83)
Constant	0.0959***	0.195***	0.291***	0.478***
	(6.01)	(6.25)	(6.36)	(6.32)
Observations	691	679	667	643
R^2	0.014	0.009	0.012	0.016

Panel D. Excess Stock Returns Since 1997.

	ER 12m	ER 24m	ER 36m	ER 60m
Cov(Tr 10y, St.)	-0.00494	-0.0423	-0.0753	-0.142**
	(-0.23)	(-1.16)	(-1.76)	(-3.22)
Constant	0.0727*	0.119	0.156*	0.225*
	(2.35)	(1.95)	(2.00)	(2.38)
Observations	264	252	240	216
R^2	0.001	0.031	0.077	0.237

Table 5: Aggregate Bond and Stock Return Predictability. Newey-West standard errors with lags corresponding to overlap in return horizon. Monthly data 1973-2020.

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Panel A.

	1973-2020		1997-2020		
	Aaa-Tr. 12m	Baa-Tr. 12m	Aaa-Tr. 12m	Baa-Tr. 12m	HY-Tr. 12m
Cov(Tr 10y, St.)	-0.0158*	-0.0303*	-0.0278**	-0.0630**	-0.0651***
	(-1.97)	(-2.05)	(-2.68)	(-3.09)	(-3.67)
Constant	-0.00376	-0.00498	-0.0197	-0.0426	-0.0399
	(-0.41)	(-0.29)	(-1.32)	(-1.47)	(-1.60)
Observations	557	557	269	269	271
R^2	0.031	0.035	0.098	0.127	0.171

Panel B.

	1973-2020		1997-2020		
	Aaa-Tr. 12m	Baa-Tr. 12m	Aaa-Tr. 12m	Baa-Tr. 12m	HY-Tr. 12m
Cov(Tr 10y, St.)	-0.0140	-0.0301*	-0.0275**	-0.0561**	-0.0611***
	(-1.79)	(-2.09)	(-2.66)	(-2.78)	(-3.44)
CP Factor	0.391	1.690	1.102	0.599	0.949
	(0.69)	(1.62)	(0.97)	(0.27)	(0.49)
BW Sentiment	-0.0209*	-0.0308	-0.0282	-0.0815*	-0.0614
	(-2.04)	(-1.63)	(-1.52)	(-2.24)	(-1.92)
Constant	-0.00709	-0.0211	-0.0253	-0.0385	-0.0406
	(-0.67)	(-1.08)	(-1.45)	(-1.13)	(-1.36)
Observations	552	552	264	264	265
R^2	0.077	0.079	0.159	0.222	0.242

Table 6: Relative Bond Return Predictability. 12-month excess returns of risky corporate bonds over equivalent maturity Treasury bonds. Newey-West standard errors with 12 lags. Bottom panel controls for the Cochrane and Piazzesi (2005) predictive factor as constructed by Hodrick and Tomunen (2018) and the Baker and Wurgler (2006) sentiment factor. Monthly data 1973-2020.

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Panel A.

	age 12m	dbe 12m	bm 12m	ebe 12m	efa 12m	gs 12m	rvol 12m
Cov(Tr 10y, St.)	0.0316*	0.0265*	-0.0197	0.0550*	-0.0238	-0.0205	-0.0961**
	(2.34)	(2.10)	(-0.90)	(2.09)	(-1.46)	(-1.42)	(-2.68)
Constant	0.0138	-0.0118	0.0727*	0.0179	-0.0980***	-0.0382	-0.0635
	(0.57)	(-0.61)	(2.23)	(0.60)	(-4.72)	(-1.79)	(-1.82)
Observations	540	552	552	552	552	552	552
R^2	0.021	0.022	0.005	0.043	0.018	0.013	0.086

Panel B.

	age 12m	dbe 12m	bm 12m	ebe 12m	efa 12m	gs 12m	rvol 12m
Cov(Tr 10y, St.)	0.0216	0.0144	-0.0224	0.0474	-0.0146	-0.0160	-0.0784*
	(1.62)	(1.12)	(-1.00)	(1.72)	(-0.90)	(-1.18)	(-2.17)
CP Factor	-1.330	0.146	1.537	-2.871	-0.375	0.214	1.889
	(-0.94)	(0.13)	(0.74)	(-1.83)	(-0.33)	(0.15)	(1.12)
BW Sentiment	0.0949***	0.0850***	-0.00529	0.102***	-0.0608*	-0.0359	-0.159***
	(3.56)	(5.43)	(-0.13)	(4.39)	(-1.96)	(-1.40)	(-5.71)
Constant	0.0279	-0.0122	0.0573	0.0479	-0.0950***	-0.0408	-0.0843*
	(0.90)	(-0.53)	(1.33)	(1.39)	(-3.46)	(-1.32)	(-2.28)
Observations	540	552	552	552	552	552	552
R^2	0.172	0.223	0.011	0.163	0.123	0.044	0.275

Table 7: Relative Equity Return Predictability. 12-month excess returns for long-short portfolios of bond-like stocks, constructed after Baker and Wurgler (2012). See text for details. Panels B controls for the Cochrane and Piazzesi (2005) predictive factor as constructed by Hodrick and Tomunen (2018) and the Baker and Wurgler (2006) sentiment factor. Monthly data 1973-2020.

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Panel A.

	age 60m	dbe 60m	bm 60m	ebe 60m	efa 60m	gs 60m	rvol 60m
Cov(Tr 10y, St.)	0.138***	0.102	0.0360	0.206**	-0.0783*	-0.101	-0.150***
	(3.56)	(1.77)	(0.35)	(2.70)	(-2.53)	(-1.66)	(-4.09)
Constant	0.0391	-0.0464	0.386*	0.115	-0.398***	-0.150	-0.288*
	(0.49)	(-0.52)	(2.10)	(0.74)	(-6.07)	(-1.58)	(-1.99)
Observations	492	504	504	504	504	504	504
R^2	0.143	0.080	0.002	0.101	0.094	0.059	0.064

Panel B.

	age 60m	dbe 60m	bm 60m	ebe 60m	efa 60m	gs 60m	rvol 60m
Cov(Tr 10y, St.)	0.116***	0.0727	0.0631	0.157**	-0.0729*	-0.0967	-0.0996*
	(4.02)	(1.57)	(0.64)	(2.75)	(-2.41)	(-1.72)	(-2.22)
CP Factor	-3.712	-1.178	-16.93**	8.861	1.083	4.123	1.549
	(-1.61)	(-0.41)	(-3.20)	(1.59)	(0.59)	(1.33)	(0.36)
BW Sentiment	0.230***	0.237***	0.0956	0.203	-0.0595	-0.103**	-0.398**
	(4.55)	(3.51)	(0.75)	(1.59)	(-1.34)	(-2.69)	(-2.70)
Constant	0.0741	-0.0357	0.554**	0.0262	-0.409***	-0.191	-0.302**
	(1.38)	(-0.51)	(2.65)	(0.24)	(-5.32)	(-1.93)	(-2.70)
Observations	492	504	504	504	504	504	504
R^2	0.459	0.441	0.106	0.270	0.138	0.117	0.447

Table 8: Relative Equity Return Predictability. 60-month excess returns for long-short portfolios of bond-like stocks, constructed after Baker and Wurgler (2012). See text for details. Panels B controls for the Cochrane and Piazzesi (2005) predictive factor as constructed by Hodrick and Tomunen (2018) and the Baker and Wurgler (2006) sentiment factor. Monthly data 1973-2020.

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Panel A.

	12-month Excess Returns over USD. 1988-2020				
	AUD	CAD	CHF	DKK	EUR
Cov(Tr 10y, St.)	-0.0467**	-0.0183	-0.0190	-0.00929	-0.0224
	(-2.90)	(-1.79)	(-1.37)	(-0.61)	(-1.37)
Constant	0.00452	-0.00371	-0.00300	0.000918	-0.0163
	(0.27)	(-0.35)	(-0.21)	(0.06)	(-0.85)
Observations	368	368	368	368	248
R^2	0.096	0.039	0.022	0.005	0.029
	GBP	JPY	NOK	NZD	SEK
Cov(Tr 10y, St.)	0.00551	-0.0176	-0.0173	-0.0401*	-0.0178
	(0.43)	(-1.18)	(-1.11)	(-2.33)	(-1.02)
Constant	0.00365	0.00342	-0.00361	0.0169	-0.0110
	(0.28)	(0.22)	(-0.22)	(0.94)	(-0.61)
Observations	368	368	368	368	368
R^2	0.002	0.018	0.015	0.066	0.013

Panel B.

	12-month Excess Returns over USD. 1996-2020				
	AUD	CAD	CHF	DKK	EUR
Cov(Tr 10y, St.)	-0.0642***	-0.0261*	-0.0342**	-0.0298*	-0.0224
	(-3.58)	(-2.22)	(-2.61)	(-1.97)	(-1.37)
Constant	-0.0156	-0.0103	-0.0233	-0.0257	-0.0163
	(-0.76)	(-0.76)	(-1.56)	(-1.49)	(-0.85)
Observations	283	283	283	283	248
R^2	0.154	0.068	0.084	0.054	0.029
	GBP	JPY	NOK	NZD	SEK
Cov(Tr 10y, St.)	0.00188	-0.0300*	-0.0335*	-0.0577**	-0.0372*
	(0.14)	(-2.02)	(-1.99)	(-2.98)	(-2.16)
Constant	-0.00359	-0.0119	-0.0239	-0.00445	-0.0346
	(-0.23)	(-0.69)	(-1.24)	(-0.20)	(-1.75)
Observations	283	283	283	283	283
R^2	0.000	0.056	0.055	0.115	0.064

Table 9: FX Return Predictability. 12-month excess returns for currency pairs over USD. Newey-West standard errors with 12 lags. Monthly data 1988-2020.

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	Cov(Treasury 10y, Stocks)			
Implied Volatility 10y	0.0390	-0.636***	-0.377***	-0.178**
	(0.75)	(-7.30)	(-4.95)	(-2.74)
Jump Probability Calls (LT)	-2.722***		-2.199***	-1.441***
	(-7.00)		(-6.86)	(-5.56)
Jump Probability Puts (RT)		1.805***	1.439***	1.151***
		(6.53)	(6.33)	(6.27)
Vol(St.)				-6.517***
				(-9.37)
Constant	-0.0461	3.126***	1.848***	1.456***
	(-0.12)	(6.44)	(4.43)	(4.33)
Observations	335	335	335	335
R^2	0.311	0.302	0.443	0.633

Table 10: Implied Volatility of Treasury Prices. Jump Probabilities of Treasury Prices. Treasury implied volatility and jump probabilities estimated from options prices on the 10-year Treasury futures contract according to Equations 1 and 2. Options data from the CME Group. Monthly data 1997-2014.

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Panel A.

	D.IG share	D.A-rated share	D.IG mat	D.IG Fin/GDP
D.Cov(Tr 10y, St.)	-0.0275*	-0.0272	-0.137	-0.242**
	(-2.17)	(-1.76)	(-0.38)	(-2.66)
Constant	-0.000297	-0.00190	-0.0134	0.0000598
	(-0.11)	(-0.60)	(-0.17)	(0.00)
Observations	355	355	356	356
R^2	0.016	0.011	0.001	0.025

Panel B.

	D.IG share	D.A-rated share	D.IG mat	D.IG Fin/GDP
D.Cov(Tr 10y, St.)	0.00676	-0.0243	-0.199	-0.380***
	(0.43)	(-1.24)	(-0.44)	(-3.32)
D.Vol(St.)	0.750***	0.0639	-1.344	-3.021*
	(4.03)	(0.27)	(-0.25)	(-2.28)
Constant	-0.000302	-0.00191	-0.0132	0.000452
	(-0.12)	(-0.60)	(-0.17)	(0.03)
Observations	355	355	356	356
R^2	0.063	0.011	0.001	0.040

Table 11: Corporate Issuance and the Stock-Bond Covariance. Bond issuance data constructed from Mergent FISD data. Monthly data 1990-2019.

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Panel A.

	D.Broker-Dealer	D.Households	D.MMF
D.Cov(Tr 10y, St.)	-0.355***	-0.0748	-0.188***
	(-5.15)	(-0.65)	(-4.03)
Constant	0.00288	0.0199	0.0287
	(0.06)	(0.26)	(0.92)
Observations	188	188	188
R^2	0.125	0.002	0.080

Panel B.

	D.Depository Inst.	D.Mutual Funds	D.Insurance
D.Cov(Tr 10y, St.)	0.0128	0.00914	-0.00407
	(0.26)	(0.40)	(-0.27)
Constant	-0.0910**	0.0357*	0.000459
	(-2.73)	(2.35)	(0.05)
Observations	188	188	188
R^2	0.000	0.001	0.000

Table 12: Holdings of Treasuries by Sector. Sectoral holdings data from Financial Accounts of the U.S. Quarterly data 1973-2020.

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Variable	Mean	S.D.	p10	p90	Skew
Instantaneous risk premium	6.392	4.449	1.637	12.153	1.398
Annualized Sharpe ratio	0.286	0.099	0.156	0.415	0.278
Instantaneous risk-free rate	1.394	4.469	-4.365	6.855	-0.311
Precautionary savings component	-4.436	2.867	-8.242	-1.210	-1.117
10-year yield	1.244	2.615	-2.164	4.257	-0.742
Monthly market return, model	0.731	5.959	-6.293	8.044	0.396
Monthly market return, data	0.661	4.402	-5.560	6.080	-0.724
Monthly 10y bond return, model	0.061	3.525	-4.307	4.525	0.127
Monthly 10y bond return, data	0.129	2.585	-2.880	3.430	0.012
Stock 10y bond covariance, model	-0.192	0.478	-0.774	0.285	-1.116
Stock 10y nominal bond covariance, data	-0.487	0.996	-1.547	0.394	-2.825
Stock 10y real bond covariance, data	-0.282	0.528	-0.839	0.144	-2.685
10y bond stock beta, model	-0.034	0.125	-0.176	0.111	1.292
10y nominal bond stock beta, data	-0.105	0.263	-0.374	0.266	0.974
10y real bond stock beta, data	-0.080	0.148	-0.264	0.103	0.311
Stock 10y nominal bond cov., inflation calibration.	0.994	0.700	0.214	1.778	-0.546
10y nominal bond stock beta, infaltion calibration.	0.362	0.297	0.039	0.741	1.207

Table 13: Model Moments. 1,000,000 days of data simulated according to parameter values in Table 1.

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	Cov(St., 10y Tr.) Model			Cov(St., 10y Tr.) Data		
L.Cov(Stocks, 10y Tr.)	0.483***			0.679***		
	(120.33)			(15.50)		
L6.Cov(Stocks, 10y Tr.)		0.116***			0.235***	
		(25.49)			(3.63)	
L12.Cov(Stocks, 10y Tr.)			0.104***			0.112
			(22.90)			(1.69)
Constant	-0.0992***	-0.170***	-0.172***	-0.192***	-0.478***	-0.561***
	(-47.99)	(-72.32)	(-73.15)	(-3.57)	(-6.58)	(-7.49)
Observations	47619	47614	47608	281	276	270
R^2	0.233	0.013	0.011	0.463	0.046	0.011

Table 14: Autocorrelation of Stock-Bond Covariance in the Model and in the Data. 1,000,000 trading days of simulated data, collapsed to monthly frequency. One "month" in the model consists of 21 trading days.

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	Cov(Stocks, 10y Bond) Model			
Price Dividend Ratio	1.058***			1.404***
	(50.92)			(11.64)
Price of Risk		-0.0624***		0.0193**
		(-55.88)		(3.12)
Dividend Growth Rate			0.236	12.74***
			(0.25)	(9.29)
Constant	-2.408***	0.266***	-0.192***	-3.271***
	(-53.64)	(38.31)	(-86.43)	(-10.97)
Observations	47620	47620	47620	47620
R^2	0.113	0.111	0.000	0.115

Table 15: 10-year Bond Beta in the Model. Bond beta as a function of price dividend ratio, price of risk, and dividend growth rate. 1,000,000 trading days of simulated data, collapsed to monthly frequency. One "month" in the model consists of 21 trading days.

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	Level Factor			Slope Factor		
Cov(Stocks, 10y Tr.)	3.442***			-0.244***		
	(42.58)			(-20.67)		
Price of Risk		-1.847***			0.132***	
		(-119.91)			(34.44)	
Dividend Growth Rate			1.016***			0.273***
			(35.41)			(132.49)
Constant	0.660***	13.55***	0.317***	-0.0467***	-0.972***	0.0853***
	(8.70)	(113.12)	(4.34)	(-4.20)	(-32.49)	(16.23)
Observations	47620	47620	47620	47620	47620	47620
R^2	0.092	0.753	0.210	0.024	0.201	0.788

Table 16: Accounting for Term Structure Factors. Level and Slope refer to the first two principal components of the simulated term structure. 1,000,000 trading days of simulated data collapsed to monthly frequency. One "month" consists of 21 trading days.

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	Bonds			Stocks		
Price Dividend Ratio	0.00326			-0.144***		
	(1.06)			(-14.45)		
Price of Risk		-0.00113			0.0744***	
		(-0.74)			(15.12)	
Stock-10y Bond Covariance			0.00194			-0.143***
			(0.59)			(-12.62)
Constant	-0.0599	0.00528	-0.00264	2.853***	-0.209***	0.309***
	(-1.11)	(0.44)	(-0.64)	(16.34)	(-5.44)	(21.49)
Observations	47560	47560	47560	47560	47560	47560
R^2	0.001	0.000	0.000	0.140	0.151	0.020

Table 17: Stock and Bond Return Predictability in the Model. 60-month excess returns on the equity market and 10-year bond. 1,000,000 days of simulated data collapsed to monthly frequency. One "month" consists of 21 trading days. Newey-West standard errors.

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	mean	p10	p90	sd
Cov(Tr 10y, St.)	-0.040	-0.992	0.846	1.013
Cov(TIPS 10y, St.)	-0.288	-0.894	0.144	0.528
Tr 10y Stock Beta	0.108	-0.326	0.605	0.358
Vol(St.)	0.142	0.077	0.225	0.083
yield 1y	5.075	0.296	9.666	3.617
yield 3y	5.484	0.947	10.204	3.471
yield 5y	5.798	1.544	10.512	3.304
yield 10y	6.311	2.346	10.667	3.025
yield 30y	5.546	3.028	8.384	2.025
Level	0.024	-5.196	5.915	3.862
Slope	-0.013	-0.851	0.660	0.552
Curvature	0.003	-0.226	0.211	0.214
Aaa-Tr	1.148	0.500	1.880	0.544
Baa-Tr	2.235	1.490	3.140	0.718
Baa-Aaa	1.087	0.670	1.680	0.451
GZ Spread	1.796	0.911	2.886	0.943
ER 12m	0.102	-0.115	0.278	0.160
ER 24m	0.213	-0.088	0.465	0.219
ER 36m	0.322	-0.063	0.607	0.262
ER 60m	0.538	0.007	0.926	0.343
Aaa-Tr. 12m	-0.004	-0.112	0.102	0.085
Baa-Tr. 12m	-0.005	-0.176	0.144	0.154
HY-Tr. 12m	-0.005	-0.142	0.119	0.157
5y 12m ER	0.021	-0.045	0.089	0.057
10y 12m ER	0.033	-0.092	0.166	0.108
20y 12m ER	0.043	-0.166	0.268	0.201
30y 12m ER	0.048	-0.234	0.354	0.315
Observations	568			

Table 18: Summary Statistics Part 1. Monthly data 1973-2019.

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	mean	p10	p90	sd
age 12m	0.018	-0.200	0.228	0.204
dbe 12m	-0.012	-0.219	0.168	0.169
bm 12m	0.073	-0.228	0.414	0.272
ebe 12m	0.018	-0.292	0.311	0.255
efa 12m	-0.098	-0.264	0.089	0.171
gs 12m	-0.038	-0.235	0.155	0.174
rvol 12m	-0.063	-0.384	0.331	0.312
age 60m	0.047	-0.377	0.548	0.356
dbe 60m	-0.044	-0.509	0.485	0.357
bm 60m	0.387	-0.375	1.513	0.789
ebe 60m	0.120	-0.520	1.162	0.638
efa 60m	-0.400	-0.839	-0.093	0.252
gs 60m	-0.152	-0.620	0.501	0.410
rvol 60m	-0.292	-0.820	0.387	0.584
CP Factor	0.010	-0.008	0.027	0.015
BW Sentiment	-0.013	-1.218	0.988	0.894
Implied Volatility 10y	7.414	5.249	9.562	1.861
Jump Probability Calls (LT)	0.161	0.000	0.450	0.231
Jump Probability Puts (RT)	0.838	0.192	1.673	0.640
IG share	0.693	0.502	0.885	0.144
A-rated share	0.314	0.133	0.528	0.159
IG mat	15.011	9.726	22.237	5.332
IG Fin/GDP	1.585	0.258	3.570	1.279
Depository Inst.	7.518	1.491	16.571	6.089
Mutual Funds	2.735	0.241	5.459	1.790
Insurance	3.421	2.040	5.809	1.410
Broker-Dealer	0.185	-1.160	1.348	0.945
Households	8.522	2.793	14.579	4.507
MMF	2.221	0.174	4.263	1.577
Observations	565			

Table 19: Summary Statistics Part 2. Monthly data 1973-2019.

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8 Figures

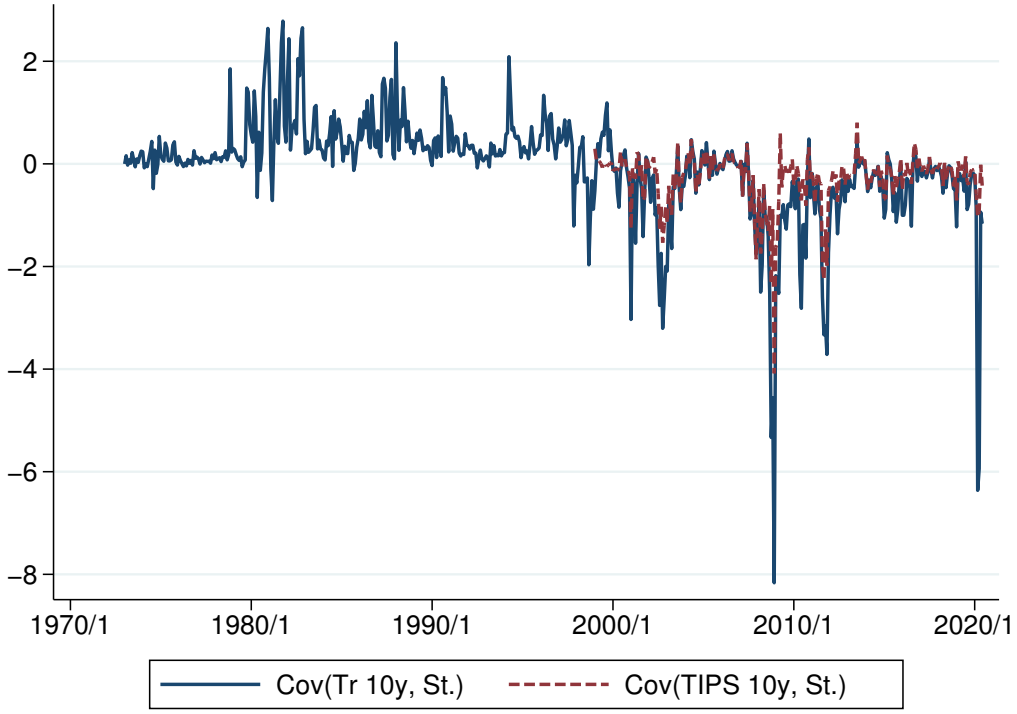


Figure 1: Stock-Bond Covariance. Monthly data 1973-2015. Covariances with the market calculated from daily using a 30 day rolling window. Plot shows monthly averages. Prices of 10-year Treasury and 10-year TIPS prices from the fitted yield curve of Gürkaynak et al. (2007).

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Figure 2: Historical Stock-Bond Covariance. Monthly data 1870-2020. Covariances calculated in a rolling window of 30 monthly observations.

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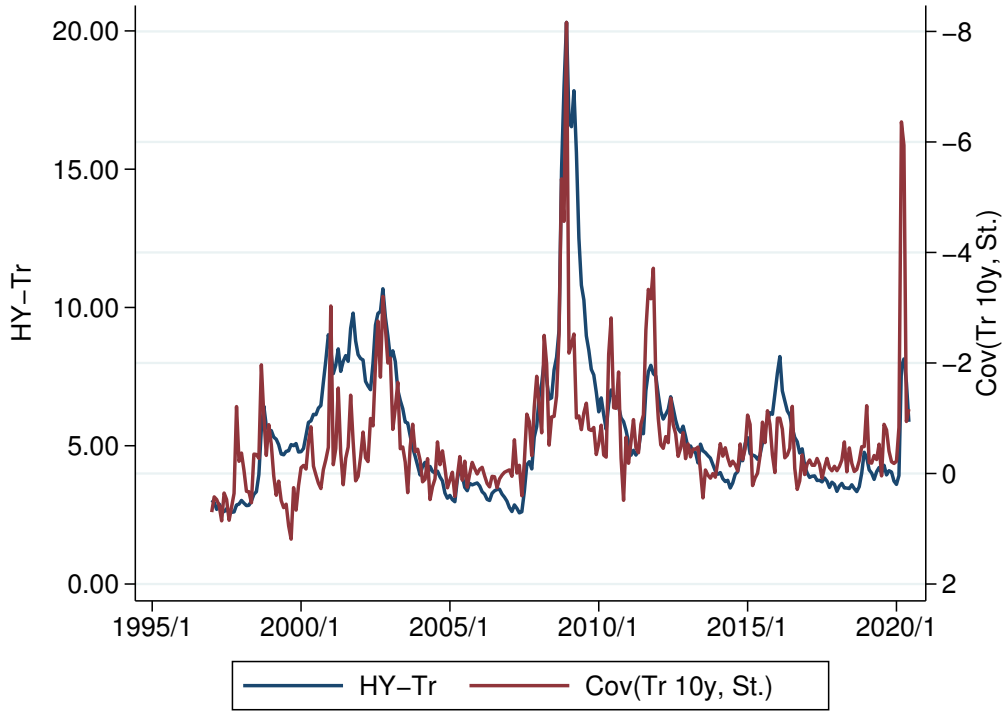


Figure 3: Stock-Bond Covariance and the High-Yield over Treasury Spread. Covariance on inverted axis. High-yield spread from Bank of America. Monthly data 1997-2020.

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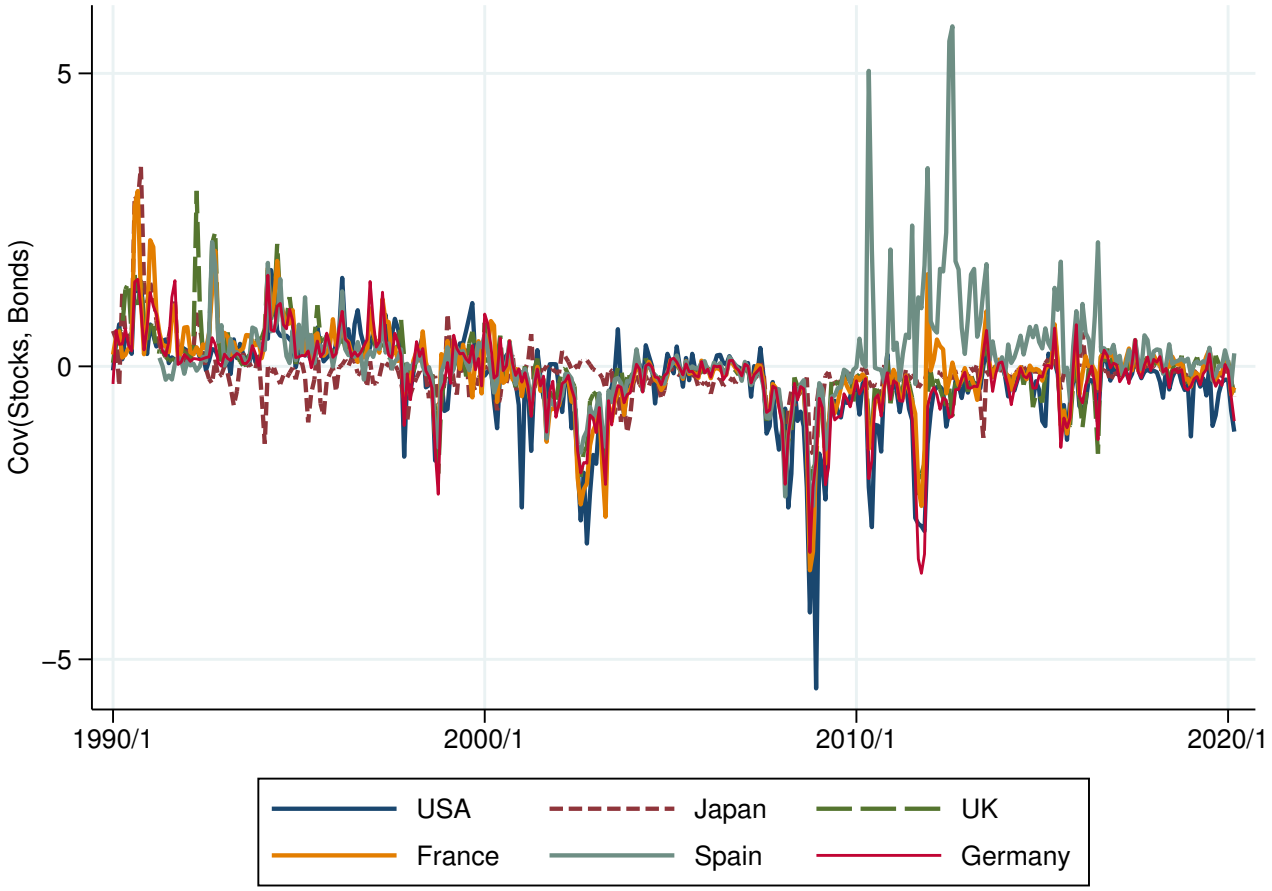


Figure 4: Local Market Stock-Bond Covariance. Monthly data 1990-2020. Daily local stock and bond market data from DataStream.

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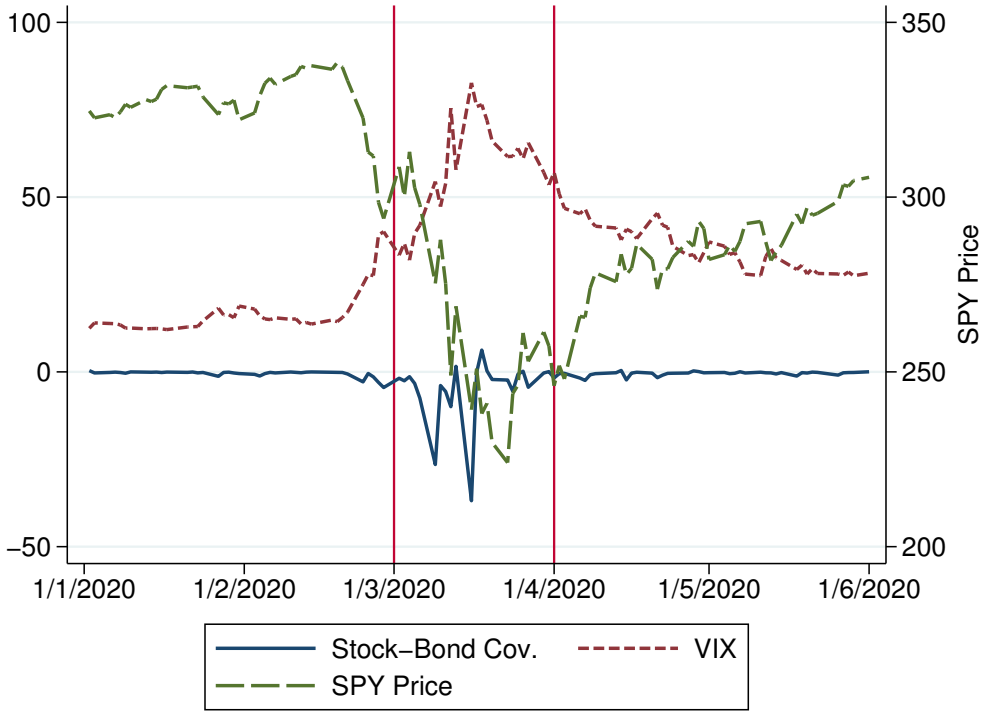


Figure 5: Stock-Bond Covariance During the Pandemic. Covariance estimated using the SPY and IEF ETF returns with 15-minute increments in a two day look-back window.

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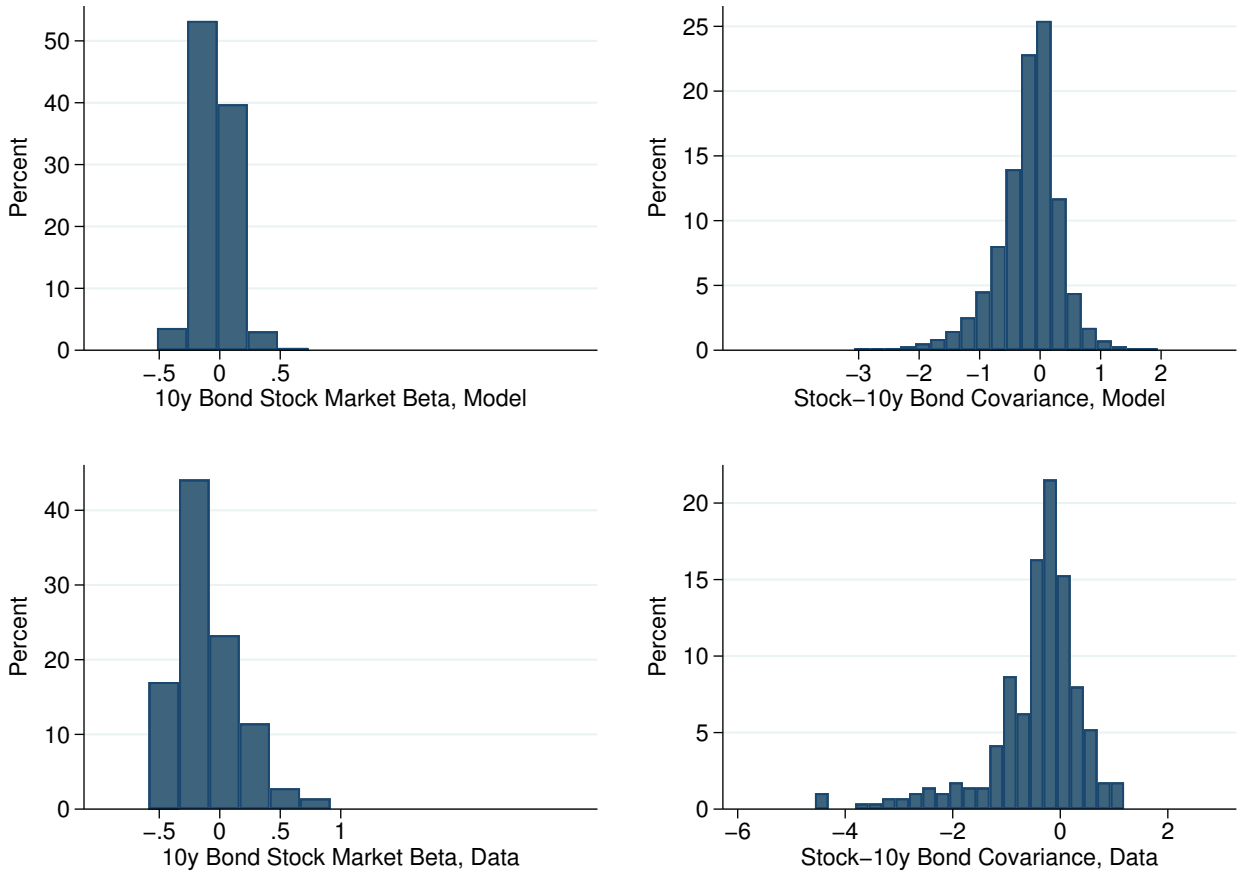


Figure 6: 10-year Treasury Bond Market Beta. Covariance of 10-year Treasury Bonds and Stocks. Distributions in the Model and in the Data. Top panel shows the model distribution, bottom panel shows the empirical distribution. The bond beta distribution is right skewed, while the covariance distribution is left skewed, just like in the data. 1,000,000 trading days of simulated data. Empirical distribution from monthly data 1997-2020.

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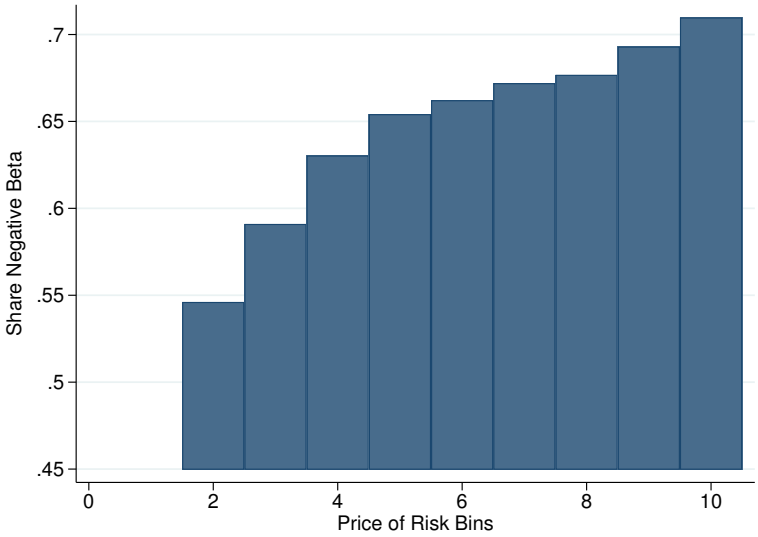


Figure 7: 10-year Treasury Bond Beta in the Model. Share of negative betas. 1,000,000 trading days of simulated data. Bond beta calculated in a rolling 21-month window.

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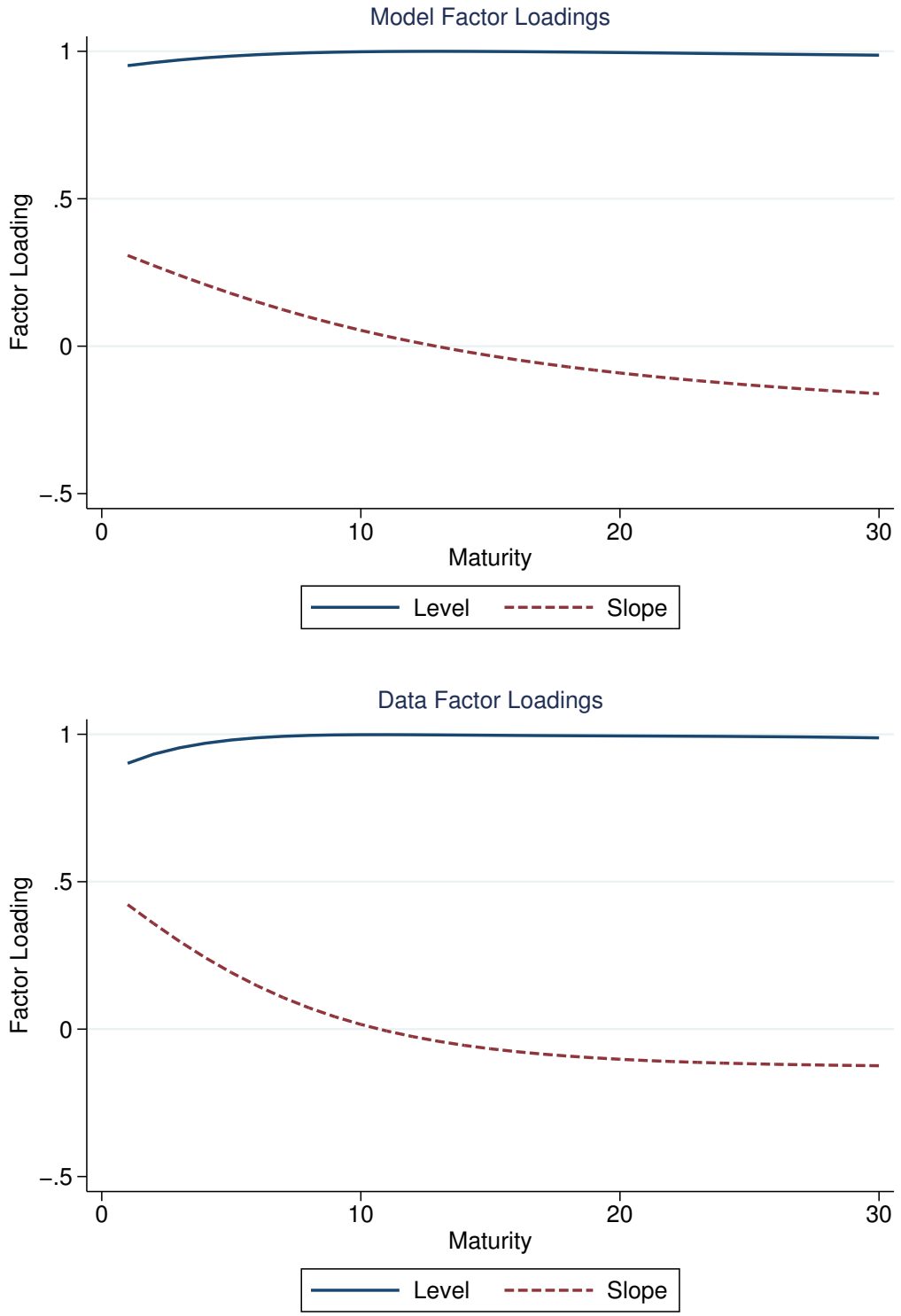


Figure 8: Yield Curve Factors in the Model and Data. Top figure shows the yield curve in the model, the bottom figure shows the yield curve factor loadings in the data.

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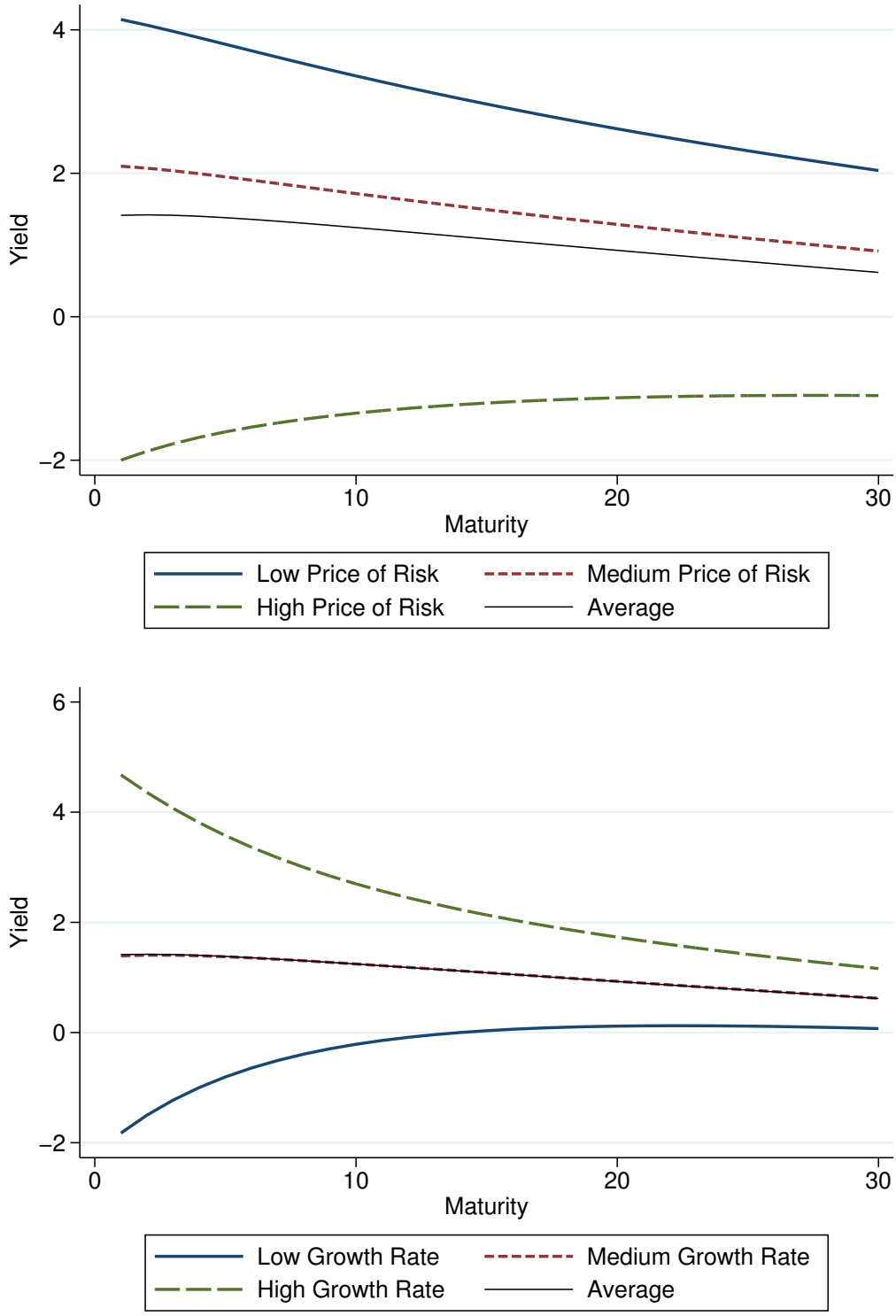


Figure 9: Yield Curve in the Model as a Function of Price of Risk x_t and Dividend Growth Rate $g + z_t$.

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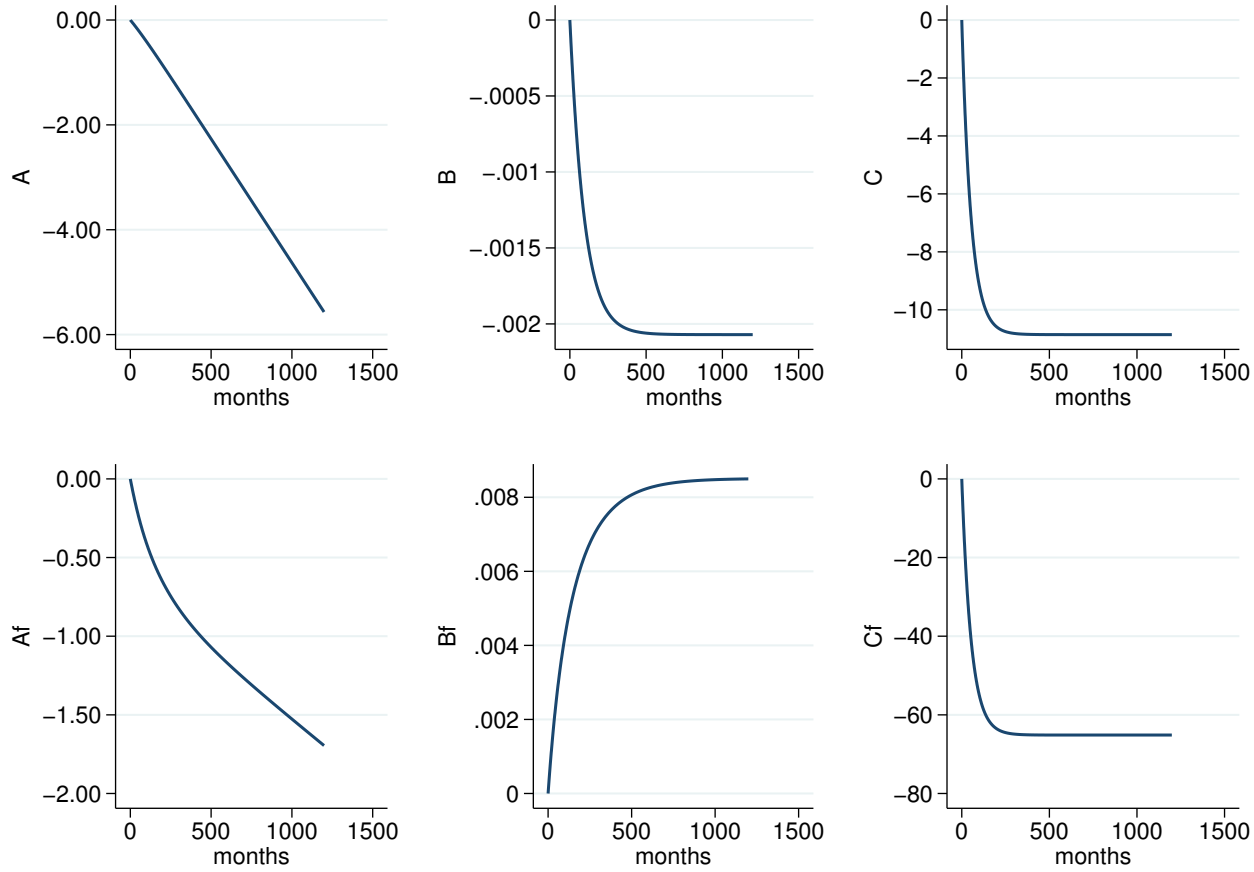


Figure 10: Risky and Safe Asset Prices in the Model. Top row shows values of constants in the pricing Equation 13. Bottom row shows values of the constants in the pricing Equation 8 for a riskless claim of maturity n.

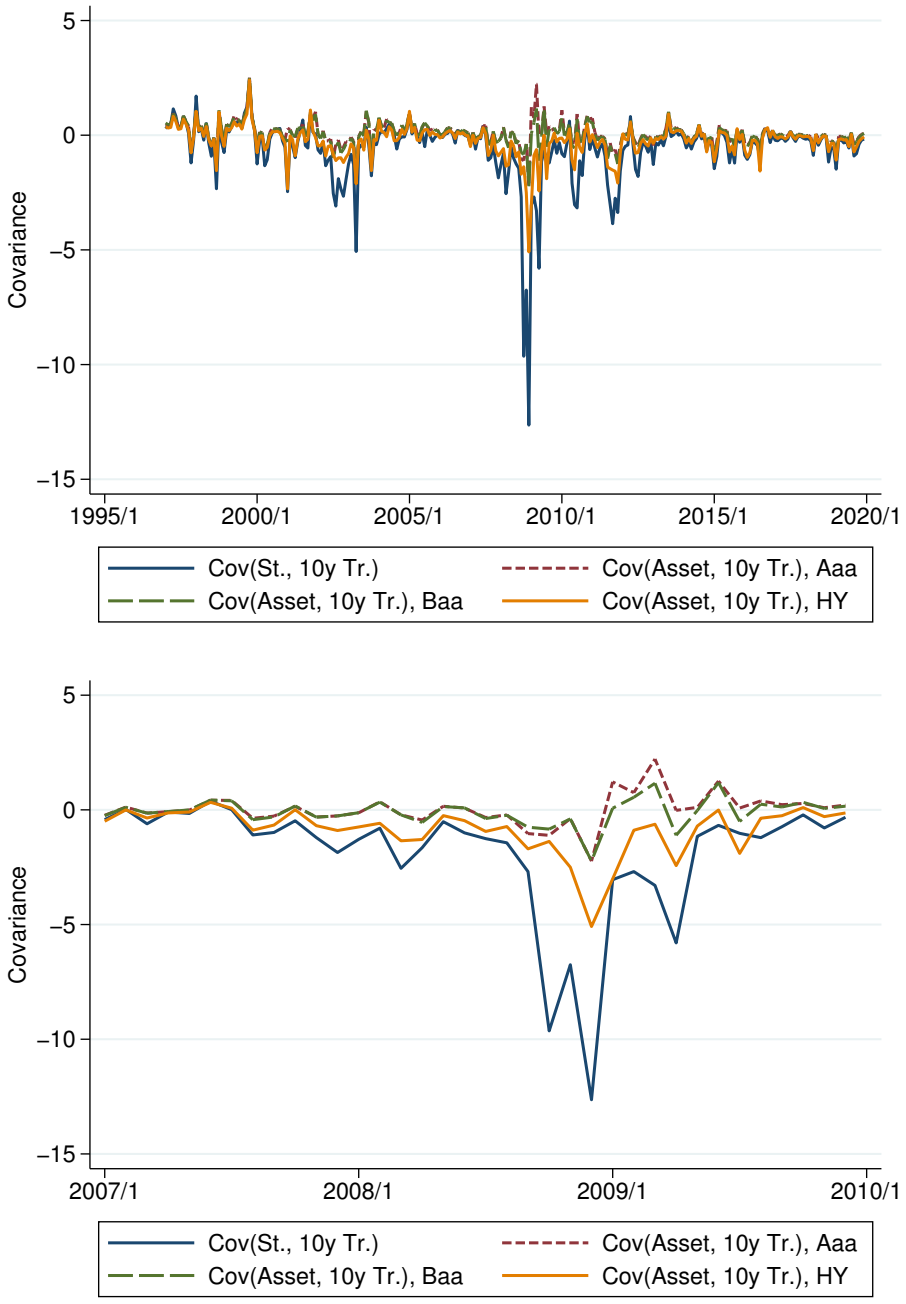


Figure 11: Asset-Bond Covariance. Asset returns are calculated using Compustat book leverage, and assuming that the debt has 10-year maturity and the credit rating indicated in the figure. Bottom panel shows the years 2007-2009 only.

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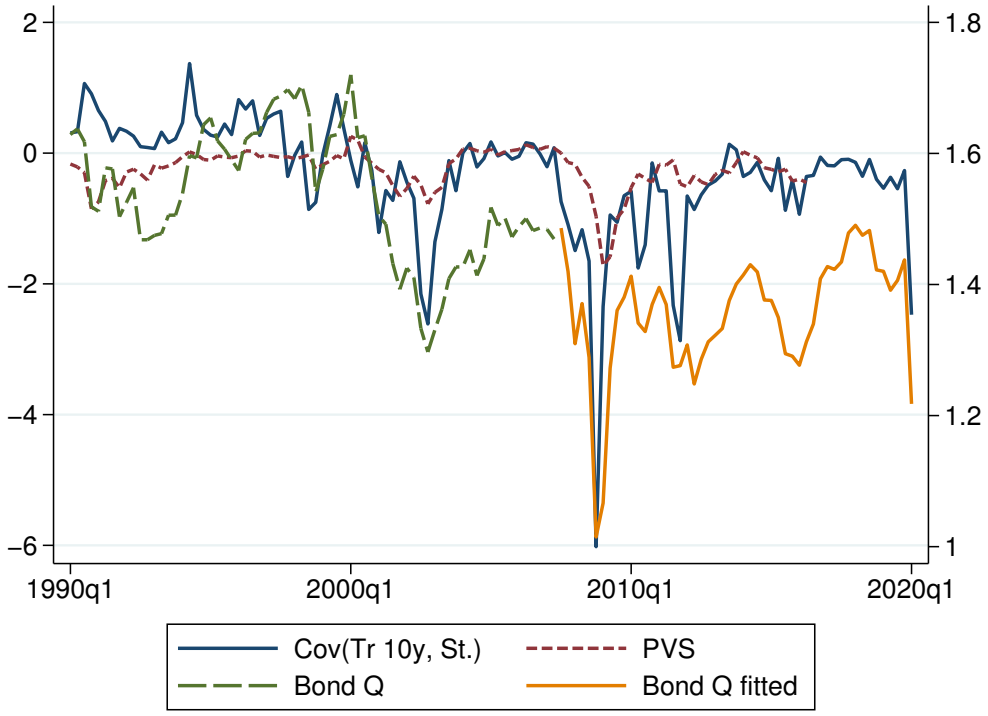


Figure 12: Stock-Bond Covariance. PVS measure from Pflueger et al. (2018). Bond Market's Q from Philippon (2009). Quarterly data 1990-2020.

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