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Abstract

We present evidence on the term structure of the equity premium. We recover prices of dividend strips, which are short-term assets that pay dividends on the stock index every period up to period T and nothing thereafter. It is short-term relative to the index because the index pays dividends in perpetuity. We find that expected returns, Sharpe ratios, and volatilities on short-term assets are higher than on the index, while their CAPM betas are below one. Short-term assets are more volatile than their realizations, leading to excess volatility and return predictability. Our findings are inconsistent with many leading theories.

Disciplines

Economics | Finance | Finance and Financial Management

Comments

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On the Timing and Pricing of Dividends[†]

By JULES VAN BINSBERGEN, MICHAEL BRANDT, AND RALPH KOIJEN*

A central question in economics is how to discount future cash flows to obtain today's value of an asset. For instance, total wealth is the price of a claim to all future consumption (Lucas 1978). Similarly, the value of the aggregate stock market equals the sum of discounted future dividend payments (Gordon 1962). The majority of the equity market literature has focused on the dynamics of the value of the aggregate stock market. However, in addition to studying the value of the sum of discounted dividends, exploring the properties of the individual terms in the sum, also called dividend strips, provides us with a lot of information about the way stock prices are formed. Analogous to zero-coupon bonds, which contain information about discount rates at different horizons for fixed income securities, having information on dividend strips informs us about discount rates of risky cash flows at different horizons. Studying dividend strips can therefore improve our understanding of investors' risk preferences and the endowment or technology process in macro-finance models. This paper is the first to empirically measure the prices of dividend strips to study the term structure of the equity premium. Our approach requires only no-arbitrage relations and does not rely on a specific model.

We shed new light on the composition of the equity risk premium. The equity premium puzzle, identified by Mehra and Prescott (1985), Hansen and Singleton (1982), and Hansen and Singleton (1983), states that, for plausible values of the risk aversion coefficient, the difference in the expected rate of return on the stock market and the riskless rate of interest is too large, given the observed small variance in the growth rate in per capita consumption. When decomposing the index into dividend strips, a natural question that arises is whether dividends at different horizons contribute equally to the equity risk premium or whether either short- or long-term dividends contribute proportionally more than the other. We find that short-term dividends have

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a higher risk premium than long-term dividends, whereas leading asset pricing models predict the opposite.

More specifically, we decompose the S&P 500 index, which is a broad US equity index, into a portfolio of short-term dividend strips, which we call the short-term asset, and a portfolio of long-term dividend strips, which we call the long-term asset. The short-term asset entitles the holder to the realized dividends of the index for a period of up to three years. Our main focus is to compare the properties of the short-term asset to those of the index, both empirically and theoretically.

In the absence of arbitrage opportunities, there exists a stochastic discount factor M_{t+1} that can be used to discount future cash flows. More formally, the value of an equity index S_t is given by the discounted value of its dividends $(D_{t+i})_{i=1}^{\infty}$:

$$S_t = \sum_{i=1}^{\infty} E_t(M_{t:t+i} D_{t+i}),$$

where $M_{t:t+i} = \prod_{j=1}^i M_{t+j}$ is the product of stochastic discount factors. We can decompose the stock index as:

$$S_t = \underbrace{\sum_{i=1}^T E_t(M_{t:t+i} D_{t+i})}_{\text{price of the short-term asset}} + \underbrace{\sum_{i=T+1}^{\infty} E_t(M_{t:t+i} D_{t+i})}_{\text{price of the long-term asset}},$$

where the short-term asset is the price of all dividends up until time T , and the long-term asset is the price of the remaining dividends. To compute the price of the short-term asset, we use a newly constructed dataset on options on the S&P 500 index.

We document five properties of the short-term asset in comparison with the aggregate stock market. First, expected returns, volatilities, and Sharpe ratios on the short-term asset are on average higher. Second, the slope coefficient (or beta) in the Capital Asset Pricing Model (Sharpe 1964 and Lintner 1965) of the short-term asset is 0.5. Third, the CAPM alpha of short-term asset returns is 9 percent per year, which suggests that the short-term asset has a substantially higher expected return than predicted by the CAPM. Fourth, the prices of the short-term asset are more volatile than their realizations, pointing to excess volatility. Fifth, the returns on the short-term asset are strongly predictable.

Our results have several important additional implications for empirical and theoretical asset pricing. First, since Shiller (1981) pointed out that stock prices are more volatile than subsequent dividend realizations, the interpretation has been that discount rates fluctuate over time and are persistent. The long duration of equity makes prices very sensitive to small persistent movements in discount rates, thereby giving rise to excess volatility in prices and returns. We show, however, that the same phenomenon arises for the short-term asset. This suggests that a complete explanation of excess volatility must be able to generate excess volatility both for the aggregate stock market and for the short-term asset. The excess variation in prices also suggests that discount rates fluctuate, and we should therefore find that prices, normalized by some measure of dividends, forecast returns on the short-term asset. We show that this is indeed the case, leading to the fifth property. Second, the

first four properties we document, combined with the fact that the CAPM alphas are virtually unaffected if we include additional well-known asset pricing factors such as size or value, suggest that short-term assets are potentially important new test assets that may be useful in cross-sectional asset pricing tests.¹

To provide a theoretical benchmark for our results, we compute dividend strips in leading asset pricing models. Recent consumption-based asset pricing models have made substantial progress in explaining many asset pricing puzzles across various markets. Even though such models are not often used to study the pricing of dividend strips, they do have theoretical predictions about the values of these securities, which we explore in this paper.² We focus on the external habit formation model of Campbell and Cochrane (1999), the long-run risks model of Bansal and Yaron (2004), and the variable rare disasters model of Gabaix (2009), which builds upon the work of Barro (2006) and Rietz (1988). We find that both the long-run risks model and the external habit formation model predict that expected returns, volatilities, and Sharpe ratios of short-term dividend strips are lower than those of the aggregate market. Further, the risk premium on short-term dividend strips in those models is near zero. In the rare disasters model, the volatilities and Sharpe ratios of short-term dividend strips are lower than the aggregate market. Expected returns, on the other hand, are equal across all maturities of dividend strips and, therefore, also equal to those on the aggregate market. Our results suggest that risk premia on the short-term asset are higher than predicted by leading asset pricing models.

Our paper relates to Lettau and Wachter (2007) and Croce, Lettau, and Ludvigson (2009). Lettau and Wachter (2007) argue that habit formation models as in Campbell and Cochrane (1999) generate higher expected returns for long-term dividend strips as shocks to the discount factor are priced. Firms with long-duration cash flows have a high exposure to such shocks and should therefore have a higher risk premium than firms with short-duration cash flows. If one adheres to the view that value firms have short-duration cash flows and growth firms have long-duration cash flows,³ this implies that there is a growth premium, not a value premium (see also Santos and Veronesi 2010). Lettau and Wachter (2007) propose a reduced-form model that generates higher expected returns for short-term dividend strips. They illustrate the correlation structure between (un)expected cash flow shocks and shocks to the price of risk and stochastic discount factor that is sufficient to generate a value premium in their model. Croce, Lettau, and Ludvigson (2009) argue that the long-run risk model as proposed by Bansal and Yaron (2004) also generates higher risk premia for long-term dividend strips. However, Croce, Lettau, and Ludvigson (2009) also show that if the agents cannot distinguish between short-term and long-term shocks, risk premia on short-term dividend strips can be higher.

¹Lewellen, Nagel, and Shanken (2010) argue that the standard set of test assets has a strong factor structure, and that it would be valuable to have new test assets.

²Notable exceptions are Lettau and Wachter (2007) and Croce, Lettau, and Ludvigson (2009). See Ludvigson (2011) for an overview of empirical tests of consumption-based asset pricing models.

³See for instance Dechow, Sloan, and Soliman (2004) and Da (2009).

I. The Market for Dividends

There are two ways to trade dividends in financial markets. First, dividend strips can be replicated using options and futures data, which is the approach we follow in this article. In 1990, the Chicago Board Options Exchange (CBOE) introduced Long-Term Equity Anticipation Securities (LEAPS), which are long-term call and put options. The owner of a call (put) option has the right to purchase (sell) the stock index at maturity at a predetermined price X . LEAPS have maturities of up to three years. The set of maturities of these claims is not constant and varies depending on the issuing cycle. On average, there are around six maturities greater than three months available at any particular time, spaced closer together for shorter maturities, and further apart for longer maturities. Second, starting around 2000, there is an over-the-counter market of dividend derivatives that allows investors to trade dividends directly. As of 2008, many of the contracts are exchange traded. Binsbergen et al. (2011) study the dynamics of prices in the dividend futures market.

To compute dividend strip prices from options data, we require only the absence of arbitrage opportunities. Under this condition, put-call parity for European options holds (Stoll 1969):

$$(1) \quad c_{i,T} + Xe^{-r_{i,T}(T-t)} = p_{i,T} + S_t - \mathcal{P}_{i,T},$$

where $p_{i,T}$ and $c_{i,T}$ are the prices of a European put and call option at time t , with maturity T , and strike price X . $r_{i,T}$ is the interest rate between time t and T . We use the symbol $\mathcal{P}_{i,T}$ to denote the value of the short-term asset, which we defined in the introduction as:

$$(2) \quad \mathcal{P}_{i,T} \equiv \sum_{i=1}^T E_t(M_{t,t+i}D_{t+i}).$$

We can rewrite (1) to obtain the price of the short-term asset:

$$(3) \quad \mathcal{P}_{i,T} = p_{i,T} - c_{i,T} + S_t - Xe^{-r_{i,T}(T-t)}.$$

This parity relation shows that purchasing the short-term asset is equivalent to buying a put option, writing a call option, buying the stocks in the index, and borrowing cash.

A second way to synthetically create the short-term asset is by using futures contracts. The owner of the futures contract agrees to purchase the stock index for a predetermined price, $F_{i,T}$, at maturity. Absence of arbitrage opportunities implies the cost-of-carry formula for equity futures:

$$(4) \quad \mathcal{P}_{i,T} = S_t - e^{-r_{i,T}(T-t)}F_{i,T}.$$

Hence, buying the short-term asset is the same as buying the stock index and selling a position in a futures contract. In both cases, the key insight we exploit is that payoffs of derivatives contracts are based on the ex-dividend price, which allows us to recover the price of the short-term asset.

II. Data and Dividend Strategies

A. Data Sources

We measure dividend prices using put-call parity in equation (1), which is a no-arbitrage relationship. To compute dividend prices as accurately as possible, we record each of the components in equation (1) within the same minute of the last trading day of each month. To this end, we use data from four different sources. First, we use a new dataset provided by the CBOE containing intraday trades and quotes on S&P 500 index options between January 1996 and October 2009. The data contain information about all option contracts for which the S&P 500 index is the underlying asset. Second, we obtain minute-level data between January 1996 and October 2009 of the index values of the S&P 500 index from Tick Data Inc. Third, the interest rate is calculated from a collection of continuously compounded zero-coupon interest rates at various maturities and provided by IvyDB (OptionMetrics). This zero curve is derived from LIBOR rates from the British Bankers' Association (BBA) and settlement prices of Chicago Mercantile Exchange (CME) Eurodollar futures.⁴ For a given option, the appropriate interest rate corresponds to the zero-coupon rate that has a maturity equal to the option's expiration date. We obtain these by linearly interpolating between the two closest zero-coupon rates on the zero curve.⁵ Fourth, to compute daily dividends, we obtain daily return data with and without distributions (dividends) from S&P index services. Cash dividends are then computed as the difference between these two returns, multiplied by the lagged value of the index.

B. Data Selection and Matching

Our data allow us to match call and put option prices and index values within a minute interval.⁶ We therefore select option quotes for puts and calls between 10 AM and 2 PM that are quoted within the same minute and match these quotes with the tick-level index data, again within the minute. Changing the time interval to either 10 AM to 11 AM or 1 PM to 2 PM has no effect on our results.

We compute dividend prices at the last trading day of the month. For a given strike price and maturity, we collect all quotes on call option contracts and find a quote on a put option contract, with the same strike price and maturity, that is quoted closest in calendar time. Of the resulting matches, we keep the ones for each strike and maturity that are quoted closest to each other in time. This typically results in a large set of matches for which the quotes are recorded within the same second of the day, making the matching procedure as precise as possible. For each of these matches, we use the put-call parity relation to calculate the price of

⁴We use data from Bloomberg to replicate the OptionMetrics yield curves and obtain very similar results.

⁵Alternative interpolation schemes give the same results at the reported precision.

⁶Using closing prices from OptionMetrics for all quantities does not guarantee that the index value and option prices are recorded at the same time and induces substantial noise in our computations; see, also, Constantinides, Jackwerth, and Perrakis (2009). For instance, the options exchange closes 15 minutes later than the equity exchange, which leads to wider bid-ask spreads in options markets during this period. OptionMetrics reports the last quote of the trading day, which is likely to fall in this 15-minute interval. We reproduced our results using OptionMetrics data and find similar results for average returns, but the volatility of prices and returns is substantially higher.

the dividend strip. We use mid quotes, which are the average of the bid and the ask quotes. We then take the median across all prices for a given maturity, resulting in the final price we use in our analysis. By taking the median across a large set of dividend prices, we mitigate potential issues related to measurement error or market microstructure noise.

To illustrate the number of matches we find for quotes within the same second, we compute the average number of quotes per maturity during the last trading day of the month in a particular year. We focus on option contracts with a maturity between one and two years. The number of quotes increases substantially over time, presumably as a result of the introduction of electronic trading. However, even in the first year of our sample, we have on average nearly a thousand matches per maturity on a given trading day for options with maturities between one and two years. At the end of our sample, this number has increased to over 20,000 matches.

C. Dividend Strategies

Holding a long position in the short-term asset has the potential disadvantage that a long position in the index is required (see equations (1) and (4)). As index replication is not costless, we also consider investing in a so-called dividend steepener. This asset entitles the holder to the dividends paid out between period T_1 and T_2 , $T_1 < T_2$. The price of the dividend steepener is given by:

$$(5) \quad \mathcal{P}_{t,T_1,T_2} = \mathcal{P}_{t,T_2} - \mathcal{P}_{t,T_1} \\ = p_{t,T_2} - p_{t,T_1} - c_{t,T_2} + c_{t,T_1} - X(e^{-r_t T_2 (T_2 - t)} - e^{-r_t T_1 (T_1 - t)}).$$

This strategy can be interpreted as buying the first T_2 periods of dividends and selling the first T_1 periods of dividends, which results in a long position in the dividends paid out between periods T_1 and T_2 . This strategy does not involve any dividend payments until time T_1 . Replicating this asset does not require a long position in the index and simply involves buying and writing two calls and two puts, in addition to a cash position. The dividend steepener is also interesting to study as a macroeconomic trading strategy, as it can be used to bet on the timing of a recovery of the economy following a recession. During severe recessions, firms slash dividends and increase them when the economy rebounds. By choosing T_1 further into the future, investors bet on a later recovery.⁷

By applying the cost-of-carry formula for equity index futures to two different maturities T_1 and T_2 , where $T_1 < T_2$, the price of the dividend steepener can also be computed as:

$$\mathcal{P}_{t,T_1,T_2} = e^{r_t T_1 (T_1 - t)} F_{t,T_1} - e^{r_t T_2 (T_2 - t)} F_{t,T_2}.$$

⁷ See also "Dividend Swaps Offer Way to Pounce on a Rebound," *Wall Street Journal*, April 2009.

In this case, the steeper involves only two futures contracts and does not require any trading of the constituents of the index. By no-arbitrage, the prices implied by equity options and futures need to coincide. Since LEAPS have longer maturities than index futures, we rely on options for our analysis.

Apart from reporting dividend prices, we also implement two simple trading strategies. The first trading strategy goes long in the short-term asset. The monthly return series on this strategy is given by:

$$(6) \quad R_{1,t+1} = \frac{\mathcal{P}_{t+1,T-1} + D_{t+1}}{\mathcal{P}_{t,T}} - 1.$$

The monthly returns series on the second trading strategy, which is the dividend steeper, is given by

$$(7) \quad R_{2,t+1} = \frac{\mathcal{P}_{t+1,T_1-1,T_2-1}}{\mathcal{P}_{t,T_1,T_2}} - 1,$$

which illustrates that this trading strategy does not return any dividend payments until time T_1 . Further details on the implementation of these strategies can be found in the online Appendix.

III. Main Empirical Results

In this section, we document the properties of the prices and returns on the short-term asset. First, we study dividend prices in Section IIIA. In Section IIIB, we study the properties of dividend returns. In the remaining subsections, we study excess volatility of dividend strip prices, and the predictability of the return series that we compute.

A. Properties of Dividend Prices

Figure 1 displays the prices of the first 6, 12, 18, and 24 months of dividends during our sample period. To obtain dividend prices at constant maturities, we interpolate over the available maturities. For instance, in January 1996, the price of the dividends paid out between that date and June 1997 is \$20. As expected, the prices monotonically increase with maturity. Violations of this condition would imply the existence of arbitrage opportunities. Further, the dividend prices for all maturities drop during the two NBER recessions in our sample period, which occur between March and November 2001 and between December 2007 and June 2009. This is to be expected, as during recessions expected growth of dividends drops and discount rates on risky cash flows are likely to increase. This effect is more pronounced for the 24-month price. The six-month price is less volatile.

As dividend prices are nonstationary over time, it is perhaps more insightful to scale dividend prices by the value of the S&P 500 index. In Figure 2, we plot the prices of the first 6, 12, 18, and 24-month dividend prices as a fraction of the index value. The ratios are highly correlated. They drop between 1997 and 2001 and slowly increase afterwards. When comparing Figure 2 with Figure 1, one interesting observation is that during the recession of 2001, both the ratio and the level of dividend

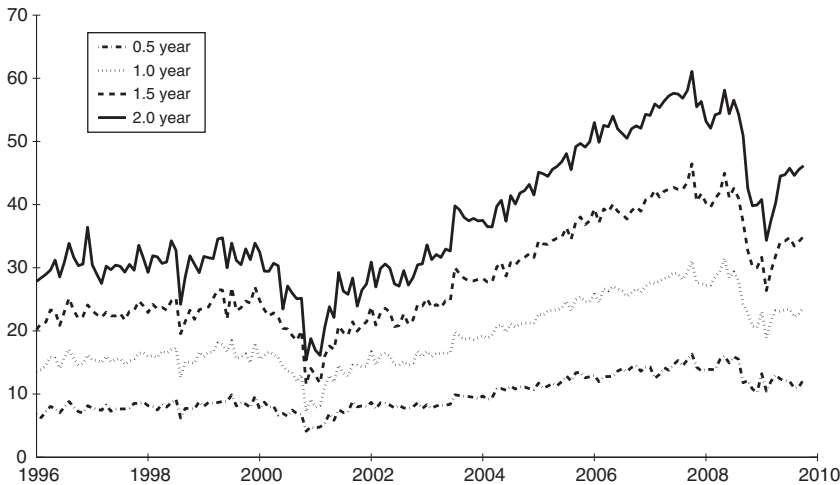
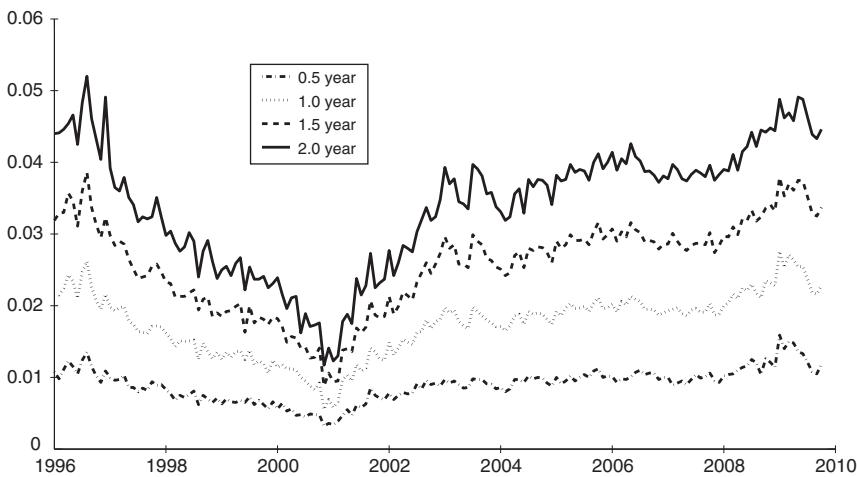


FIGURE 1. PRICE DYNAMICS OF THE SHORT-TERM ASSETS

Notes: The graph shows the prices of the first 0.5, 1, 1.5, and 2 years of dividends. The sample period is January 1996 up to October 2009.

FIGURE 2. PRESENT VALUE OF DIVIDENDS AS A FRACTION OF THE INDEX VALUE (*Cumulative*)

Notes: The graph shows the net present value of the first 0.5, 1, 1.5, and 2 years of dividends as a fraction of the index value. The sample period is January 1996 up to October 2009.

prices drop, whereas for the recent recession the level of dividend prices drops, but not by as much as the index level. This leads to an increase in the ratio. One interpretation of this finding is that the most recent recession has a longer-lasting impact than the recession in 2001. The index level is more sensitive to revisions in long-term cash flow (dividend) expectations and discount rates than the short-term asset; see Shiller (1981) and Lettau and Wachter (2007). A more severe recession can therefore lead to a decline in the index value that is proportionally larger than the decline in the price of the short-term asset.

TABLE 1—SUMMARY STATISTICS

	$R_{1,t}$	$R_{1,t} - R_{f,t}$	$R_{2,t}$	$R_{2,t} - R_{f,t}$	$R_{SP500,t}$	$R_{SP500,t} - R_{f,t}$
Mean	0.0116 (0.0044)	0.0088 (0.0044)	0.0112 (0.0044)	0.0084 (0.0045)	0.0056 (0.0047)	0.0027 (0.0047)
Standard deviation	0.0780 (0.0136)	0.0781 (0.0136)	0.0965 (0.0171)	0.0966 (0.0171)	0.0469 (0.0050)	0.0468 (0.0050)
Sharpe ratio	0.1124 (0.0520)	— —	0.0872 (0.0494)	— —	0.0586 (0.1058)	— —
Observations	165	165	165	165	165	165

Notes: The table presents descriptive statistics of the monthly returns on the two trading strategies described in the main text. Block bootstrapped standard errors (blocks of 15 observations) of each of the moments are in parentheses. Sample period is February 1996 through October 2010.

B. Properties of Dividend Returns

We now report the return characteristics of the two investment strategies. The average maturity of the returns of investment strategy 1 is 1.6 years, and it fluctuates between 1.9 and 1.3 years. The two trading strategies are highly positively correlated, with a correlation coefficient of 92 percent. Table 1 lists the summary statistics alongside the same statistics for the S&P 500 index for the full sample period. In parentheses below, we list block bootstrapped standard errors of each of these statistics. Both dividend strategies have a high monthly average return equal to 1.16 percent (annualized 14.8 percent) for trading strategy 1 and 1.12 percent (annualized 14.3 percent) for trading strategy 2 (the steepener). Over the same period, the average return on the S&P 500 index was 0.56 percent (annualized 6.93 percent). The average excess return is 0.88 percent per month for trading strategy 1 and 0.84 percent for trading strategy 2. Note that all these averages are statistically different from zero at conventional significance levels. Formal tests are presented later. We also compute the average annual excess returns using monthly overlapping data of annual returns. We find that the risk premium equals 8.35 percent for trading strategy 1 and 5.37 percent for trading strategy 2. For the S&P 500, the average annual excess return equals 2.75 percent during this sample period. In the online Appendix, we also present the cumulative returns on both trading strategies, the S&P 500, and the 30-day T-bill return. This illustrates once more that the dividend strategies result in substantially higher returns than 30-day T-bill returns.

The higher average returns also come with a higher level of volatility than the S&P 500 index, with monthly return volatilities of 7.8 percent for strategy 1 and 9.6 percent for strategy 2. Over the same period the monthly volatility of the return on the S&P 500 index equals 4.7 percent. Despite the higher volatility, the dividend strategies result in substantially higher Sharpe ratios, defined as the ratio of the average monthly excess returns and the volatility of the excess returns (Sharpe 1966). The Sharpe ratios of the dividend strategies are about twice as high as the Sharpe ratio of the S&P 500 index. Duffee (2010) shows that Sharpe ratios are lower for Treasury bonds with longer maturities. We document a similar property in equity markets; Sharpe ratios are higher for dividend claims with shorter maturities.

TABLE 2—ESTIMATES OF THE GARCH(1,1) MODEL

Dependent variable	$R_{1,t+1}$	$R_{2,t+1}$	$R_{SP500,t+1}$
Mean equation			
c	0.0074 (0.0047)	0.0085 (0.0042)	0.0070 (0.0038)
AR(1)	-0.2682 (0.0973)	-0.3668 (0.1056)	0.0898 (0.0958)
Variance equation			
c	1.5×10^{-4} (7.4×10^{-5})	2.4×10^{-4} (1.4×10^{-4})	7.2×10^{-5} (6.6×10^{-5})
Squared residual	0.1138 (0.0347)	0.1724 (0.0536)	0.1859 (0.0722)
GARCH(1)	0.8773 (0.0263)	0.8287 (0.0680)	0.8056 (0.0639)

Notes: The top panel provides the estimates of the mean equation; the bottom panel displays the estimates of the variance model. The first two columns report the results for the dividend return strategies, and the third column provides the results for the S&P 500.

We find that the volatility of dividend returns is lower in the second part of our sample. To further analyze the volatility of dividend returns, we estimate a GARCH(1,1) model (Bollerslev 1986) for each return series and for the returns on the S&P 500 index. As the returns on the dividend strategies are predictable (see Section III E), we include an AR(1)-term in the mean equation. In Figure 3, we show that the volatility of dividend returns and the index broadly follow the same pattern. The correlation between the volatility of the dividend returns of strategy 1 and the S&P 500 index is 0.55. Table 2 reports the estimates of the GARCH(1,1)-specification, illustrating that the parameters of the volatility equations are very similar as well.

To further assess the difference in volatility between the early and the late part of our sample, Table 3 also presents summary statistics for the period before January 2003 (panel A) and for the period afterwards (panel B). We are mostly interested in the average return and volatility of the dividend strategies relative to the same statistics of the S&P 500 index. Consistently across both sample periods, the average return and the volatility on the dividend strategies is higher than the average return and volatility of the S&P 500 index. The volatility of the dividend strategies is high in both subperiods, even though the volatilities in the more recent sample are closer to the levels of volatility that we record for the index. The Sharpe ratios of the dividend strategies are comparable across subperiods, and always higher than the ones of the S&P 500 index. Overall, the conclusions we draw from the full sample are consistent with our findings in both subsamples.

The high average returns on short-maturity dividend strips may be due to exposures to systematic risk factors that are priced in financial markets. To verify whether well-known empirical asset pricing models, such as the CAPM and the Fama and French three-factor model (Fama and French 1993), can explain the average returns on short-maturity dividend strips, we regress excess returns of both strategies on (i) the excess return on the S&P 500 (sp500rf) and (ii) on Fama and French's three factors constructed using firms in the S&P 500 only (sp500rf, hml-sp500 and

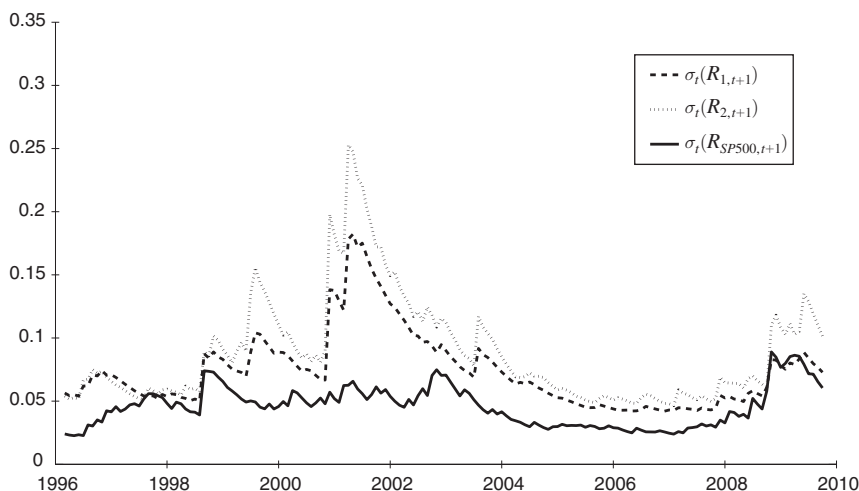


FIGURE 3. VOLATILITY OF DIVIDEND RETURNS AND RETURNS ON THE S&P 500
BASED ON A GARCH(1, 1) MODEL

smb-sp500). The three Fama-French factors are (i) the excess returns on the index (sp500rf), (ii) the returns on a portfolio that goes long in stocks with a high book-to-market ratio, also called value stocks, and short in stocks with a low book-to-market ratio, also called growth stocks (hml-sp500), and (iii) the returns on a portfolio that goes long in smaller stocks and short in larger stocks (smb-sp500). To construct the three factors using the stocks in the S&P 500, we follow the same construction procedure as Fama and French.⁸

Table 4 presents OLS regressions of the returns of the two trading strategies in excess of the one-month short rate on a constant and the S&P 500 returns in excess of the one-month short rate (the CAPM). We find that both dividend strategies have a CAPM beta (or slope) of around 0.5. Secondly, R^2 values of the regression are rather low. The intercept (also called CAPM alpha) of the regression equals 0.75 percent for the first dividend strategy and 0.71 percent for the second strategy (the steeper), which in annualized terms corresponds to 9.4 percent and 8.9 percent respectively. Despite these economically significant intercepts, the results are not statistically significant at conventional levels using asymptotic standard errors, due to the substantial volatility of these two return strategies and the rather short time series that is available for dividend returns. Generally, the p -values vary between 10 percent and 20 percent, using Newey-West standard errors.⁹ When including an AR(1) term in the regression, to account for the negative autocorrelation (predictability) in returns, the standard errors are somewhat smaller.

Table 5 presents regression results for the three-factor model. The CAPM beta, that is, the slope coefficient on the excess returns on the S&P 500 index (labeled

⁸We refer to http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html for the construction of the Fama and French factors.

⁹If instead of excess returns on the S&P 500 returns, we use excess returns on the aggregate market portfolio, which includes several thousand stocks, we find almost identical results; see the online Appendix.

TABLE 3—SUMMARY STATISTICS SUBSAMPLES

	$R_{1,t}$	$R_{2,t}$	$R_{SP500,t}$
<i>Panel A. First half sample 1996:2–2002:12</i>			
Mean	0.0159	0.0139	0.0065
Median	0.0117	0.0231	0.0093
Standard deviation	0.0986	0.1212	0.0514
Sharpe ratio	0.1242	0.0843	0.0564
Observations	83	83	83
<i>Panel B. Second half sample 2003:1–2009:10</i>			
Mean	0.0072	0.0086	0.0046
Median	0.0058	0.0086	0.0118
Standard deviation	0.0494	0.0630	0.0422
Sharpe ratio	0.1060	0.1044	0.0615
Observations	82	82	82

Note: The table presents descriptive statistics of the monthly returns on the two trading strategies described in the main text for two subsamples: 1996:2–2002:12 and 2003:1–2009:10.

TABLE 4—MONTHLY RETURNS ON THE TWO TRADING STRATEGIES AND THE S&P 500 INDEX

Dependent variable	$R_{1,t+1} - R_{f,t}$		$R_{2,t+1} - R_{f,t}$	
	<i>c</i>	0.0075 (0.0051)	0.0071 (0.0058)	0.0071 (0.0052)
sp500rf	0.4488 (0.1620)	0.4766 (0.1526)	0.4863 (0.1765)	0.5228 (0.1600)
AR(1)	— —	−0.2857 (0.1031)	— —	−0.3244 (0.0814)
R^2	0.0725	0.1542	0.0556	0.1611

Notes: The table presents OLS regressions of the returns on trading strategies 1 and 2 (dependent variables) on the excess returns on the S&P 500 index. Newey-West standard errors in parentheses. When an AR(1) term is included, the intercept is adjusted by one minus the AR(1) coefficient, such that the intercept is comparable to the regressions without AR(1) term.

sp500rf), is hardly affected by the additional factors and is estimated at around 0.4, depending on the strategy and specification. We find positive loadings on the value factor (hml-sp500), which seems consistent with duration-based explanations of the value premium. An important element of this theory is that the portfolio of value firms have cash flows that are more front-loaded than the cash flows of the portfolio of growth firms. As such, this theory suggests that the short-term asset loads more on value firms than on growth firms, which corresponds to a positive coefficient on the book-to-market factor. The coefficient on the size portfolio switches sign depending on the specification and has very low significance.

Perhaps most interestingly, the intercepts (or alphas) are hardly affected by including additional factors; monthly alphas are estimated between 0.61 percent and 0.66 percent. These results suggest that the short-term asset has rather high expected returns that cannot be explained easily by standard empirical asset pricing models. As a comparison, the monthly value premium over our sample period for

TABLE 5—MONTHLY RETURNS ON THE TWO TRADING STRATEGIES AND THE THREE S&P 500 FACTORS

Dependent variable	$R_{1,t+1} - R_{f,t}$	$R_{2,t+1} - R_{f,t}$
<i>c</i>	0.0061 (0.0047)	0.0066 (0.0056)
sp500rf	0.3972 (0.1824)	0.4137 (0.2058)
hml-sp500	0.1526 (0.1752)	0.5668 (0.1994)
smb-sp500	0.3043 (0.3117)	-0.0528 (0.3614)
R^2	0.1000	0.1011

Notes: The table presents OLS regressions of the returns on trading strategies 1 and 2 (dependent variables) on the Fama-French three factor model, where the three factors are constructed using S&P 500 firms only. Newey-West standard errors in parentheses.

hml-sp500 is a mere 0.16 percent per month (1.9 percent annualized). This suggests that the high expected returns for our dividend strategies are not (solely) driven by value firms (or small firms) in the S&P 500 index.¹⁰

The high monthly alphas compensate investors for the risk in the dividend strategies that cannot be explained by other priced factors. Our results become even more striking, however, if we account for the fact that dividend growth rates are, to some extent, predictable; see, for instance, Lettau and Ludvigson (2005); Ang and Bekaert (2007); Chen, Da, and Priestley (2009); and Binsbergen and Koijen (2010).

C. Excess Volatility of Short-Term Dividend Claims

Shiller (1981) points out that equity prices are more volatile than subsequent dividends, which is commonly known as excess volatility. One explanation has been that discount rates fluctuate over time and are persistent. The long duration of equity makes prices very sensitive to small movements in discount rates, thereby giving rise to excess volatility.

Since we study short-term claims, we can directly compare prices to subsequent realizations. Figure 4 plots the price of the next year of dividends and the realized dividends during the next year.¹¹ We shift the latter time series such that the price and subsequent realization are plotted at the same date to simplify the comparison. This illustrates that the high volatility of dividend returns is mostly coming from variation in dividend prices as opposed to their realizations, pointing to excess volatility of the short-term asset. An explanation of the excess volatility puzzle therefore

¹⁰If we use the standard Fama-French three factor model as published on Ken French's website, we find highly comparable results to the ones reported in Table 5. The only difference is that the value premium (the average return on hml) over this sample period is just above 4 percent. However, because the estimated coefficient on the hml factor is lower than the estimated coefficient on the hml-sp500 factor, the alphas for the standard Fama-French three factor model are very similar to the ones reported in Table 5; see the online Appendix.

¹¹At the end of 2004, Microsoft paid a one-time large dividend. Even though this dividend payment substantially increased the dividend yield on Microsoft stock, Microsoft's weight in the S&P 500 index was (and is) around 2–3 percent. As a consequence, this dividend does not substantially affect the aggregate dividend series.

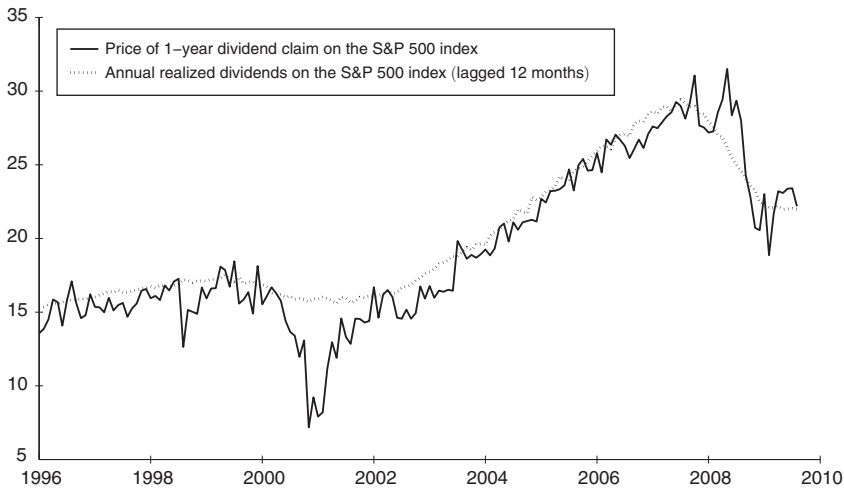


FIGURE 4. PRICES AND REALIZATIONS OF DIVIDEND CLAIMS: 1996:1–2009:10

ideally accounts for both the excess volatility of the equity index as well as that of the short-term asset. If dividend growth is i.i.d., a persistent and slow-moving discount rate may be able to produce sufficient excess volatility for the index but will induce too little excess volatility for the short-term asset.

D. Tests on Summary Statistics

In Table 6 we present a set of test statistics regarding our main findings. We present the t -statistics and the block-bootstrapped, one-sided critical values of our tests to properly take account of the small sample properties of our data as well as to maintain the time series dependencies. To illustrate the importance of block bootstrapping, we present results for regular bootstrapping, block bootstrapping with blocks of five observations, and block bootstrapping with blocks of 15 observations. For both dividend strategies the hypothesis that the average return is zero can be rejected at conventional significance levels. More importantly, we can also reject the null hypothesis that the average excess return on both dividend strategies is zero. This is an important finding as several leading asset pricing models predict that this risk premium is low and close to zero. Over the same sample period, we cannot reject the null hypothesis that the risk premium on the S&P 500 index is zero. We also formally test whether the risk premium on the dividend strategies is higher than the risk premium on the index. We cannot reject this null hypothesis at conventional significance levels.

E. Predictability of Dividend Returns

The previous section shows that prices are more variable than subsequent realizations. This suggests that discount rates fluctuate over time, which, in turn, implies that we need to be able to uncover a predictable component in the returns on the dividend strategies (Shiller 1981). We regress monthly dividend returns from trading

TABLE 6—TEST STATISTICS

Null hypothesis	<i>t</i> -statistics	Block size Confidence level	Critical values					
			1		5		15	
			90%	95%	90%	95%	90%	95%
$E(R_{1,t}) = 0$	1.91		1.28	1.64	1.02	1.31	0.86	1.11
$E(R_{1,t} - R_{f,t}) = 0$	1.44		1.28	1.64	1.03	1.32	0.88	1.14
$E(R_{2,t}) = 0$	1.49		1.27	1.62	0.94	1.20	0.74	0.95
$E(R_{2,t} - R_{f,t}) = 0$	1.12		1.27	1.62	0.95	1.22	0.77	0.99
$E(R_{1,t} = R_{SP500,t})$	0.97		1.23	1.56	1.09	1.40	1.24	1.58
$E(R_{2,t} = R_{SP500,t})$	0.75		1.23	1.56	0.89	1.15	0.94	1.20
$E[R_{SP500,t}] = 0$	1.52		1.32	1.72	1.51	1.94	1.75	2.23
$E[R_{SP500,t} - R_{f,t}] = 0$	0.75		1.32	1.72	1.56	1.99	1.79	2.28

Notes: The table presents *t*-statistics and the bootstrapped, one-sided critical values for a range of hypotheses related to the moments of the monthly returns on the two trading strategies described in the main text compared to the moments of the S&P 500 index. We use block-bootstrapped critical values to capture the small sample properties of the test statistics, as well as the time series dependence of the observations.

strategy 1 on the lagged log price-dividend ratio of the short-term asset.¹² We compute this price-dividend ratio, denoted by \mathcal{PD}_t , by taking the 1.5 year dividend strip price at time *t* and dividing it by the sum of the past 12 realized dividends:

$$(8) \quad \mathcal{PD}_t = \frac{\mathcal{P}_{t,t+18}}{\sum_{s=t-11}^t D_s}.$$

The results are presented in the second column of Table 7. We find that \mathcal{PD}_t forecasts dividend returns with a negative sign and is highly significant. This suggests that when the price of the short-term asset is high relative to the past 12 months of realized dividends, the expected return on dividend strategy 1 is low. We use both OLS standard errors (in parentheses) and Newey-West standard errors (in brackets) to determine the statistical significance of the predictive coefficient. For both sets of standard errors, the results are significant at conventional significance levels. To mitigate concerns regarding measurement error in the predictor variable, we perform two additional regressions. First, we use as the regressor $\ln(\mathcal{PD}_{t-2})$, that is, the log price-dividend ratio from the end of the previous quarter, instead of the previous month. Second, we take an average over the past three price-dividend ratios and use this predictor variable instead.¹³ More formally, the smoothed price-dividend ratio, $\ln \overline{\mathcal{PD}}_t$, is given by:

$$(9) \quad \overline{\ln(\mathcal{PD}_t)} \equiv \frac{\ln \mathcal{PD}_t + \ln \mathcal{PD}_{t-1} + \ln \mathcal{PD}_{t-2}}{3}.$$

¹²See, among others, Fama and French (1988); Campbell and Shiller (1988); Cochrane (1992); Cochrane (2008); Lettau and Van Nieuwerburgh (2008); Wachter and Warusawitharana (2009); and Binsbergen and Koijen (2010) for the predictability of returns by the price-dividend ratio or the dividend yield for the aggregate market.

¹³See Cochrane and Piazzesi (2005) for a similar treatment of measurement error in the forecasting variable of, in their case, bond returns.

TABLE 7—RETURN PREDICTABILITY

Dependent variable	$R_{1,t+1}$			$R_{SP500,t+1}$			
Constant	0.0787 (0.0147) [0.0239]	0.0437 (0.0157) [0.0229]	0.0604 (0.0162) [0.0257]	Constant	0.0653 (0.0630) [0.0941]	0.0802 (0.0641) [0.0886]	0.0781 (0.0646) [0.0929]
$\ln(PD_t)$	-0.1791 (0.0362) [0.0561]	— — —	— — —	$\ln(PD_t)$	-0.0146 (0.0154) [0.0227]	— — —	— — —
$\ln(PD_{t-2})$	— — —	-0.0863 (0.0385) [0.0527]	— — —	$\ln(PD_{t-2})$	— — —	-0.0183 (0.0157) [0.0214]	— — —
$\overline{\ln(PD_t)}$	— — —	— — —	-0.1311 (0.0401) [0.0607]	$\overline{\ln(PD_t)}$	— — —	— — —	-0.0178 (0.0158) [0.0224]
R^2	0.1320	0.0307	0.0631	R^2	0.0056	0.0085	0.0079

Notes: Column 2 shows the regression results of the monthly returns of trading strategy 1, $R_{1,t+1}$, on the price-dividend ratio of the short-term asset at time t (a lag of one month), computed as the ratio of the 1.5-year dividend strip price at time t , denoted by $\mathcal{P}_{t,t+18}$, and the sum of dividends paid out over the past 12 months. In column 3, we redo the analysis of column 2, but now lag the price-dividend ratio by two more months (one quarter in total). In column 4, we use as the regressor the smoothed price-dividend ratio of the short-term asset computed as the equal-weighted average over periods $t, t-1$ and $t-2$. OLS standard errors are in parentheses, and Newey-West standard errors are in brackets. In columns 6 through 8, we repeat the analysis of columns 2 through 4 for the S&P 500 index. We take monthly returns on the S&P 500 index ($R_{SP500,t+1}$) and regress those on various lags of the price-dividend ratio of the S&P 500 index, computed as the index value at time t , divided by the sum of dividends paid out over the past 12 months.

The results are reported in the third and fourth column of Table 7 and are comparable to the first column: the price-dividend ratio enters with a negative sign and is significant at conventional levels.

To further illustrate the strength of these predictability results, we present in columns 6 through 8 the same regressions, but now for the S&P 500 index. We regress monthly returns on the index (including distributions) on the lagged log price-dividend ratio, computed as the ratio of the index level at time t and the sum of the past 12 realized dividends (PD_t). In this case, the sign of the coefficient on the price-dividend ratio is also negative, implying that a high price-dividend ratio is indicative of low expected returns. However, over this sample period, both the R^2 and the statistical significance for the index are substantially lower than for the dividend strategy.

IV. Comparison with Asset Pricing Models

To provide a theoretical benchmark for our results, we compute dividend strips in several leading asset pricing models in this section. Recent consumption-based asset pricing models have made substantial progress in explaining many asset pricing puzzles across various markets. Even though such models are not often used to study the pricing of dividend strips, they do have theoretical predictions about their values. We consider the Campbell and Cochrane (1999) external habit formation model, the Bansal and Yaron (2004) long-run risk model, and the Barro-Rietz rare disasters framework (Rietz 1988 and Barro 2006) as explored by Gabaix (2009) and Wachter (2010). We focus on the calibration of Gabaix (2009) in this case.

The habit model and the long-run risk model imply that the risk premium and volatility of long-term dividend claims are higher. The risk premium on the short-term asset is virtually zero and lower than on the aggregate stock market, which is contrary to what we measure in the data. In the rare disasters model, expected returns are constant across maturities, but the volatilities are higher for long-term dividend claims than for short-term claims. To generate these results, we use the original calibrations that are successful in matching facts about the aggregate stock market. It is important to keep in mind, though, that such models have a relatively simple shock structure and have not been calibrated to match prices of dividend strips. It may be possible to consider alternative calibrations or model extensions that do match the features of the dividend strip prices we report.

We also consider the model of Lettau and Wachter (2007), who exogenously specify the joint dynamics of cash flows and the stochastic discount factor to match the value premium. In their model, expected returns and volatilities of the short-term asset are higher than on the aggregate stock market, and the CAPM beta of the short-term asset is below one, resulting in a substantial CAPM alpha. These features of their model are in line with our empirical findings.

For all models, we describe the intuition and main results below. In the online Appendix, we summarize the key equations necessary to compute the returns on dividend strips within the models.

A. External Habit Formation Model

In the external habit formation model of Campbell and Cochrane (1999), the consumption dynamics are the same as in the standard Lucas model. Dividend growth is assumed to be i.i.d., but shocks to dividend growth rates have a correlation of 20 percent with shocks to consumption growth rates. Furthermore, the agent is assumed to have external habit formation preferences. The habit level is assumed to be a slow-moving and heteroskedastic process. The heteroskedasticity of the habit process, the sensitivity function, is chosen so that the real interest rate in the model is constant.¹⁴ Further details can be found in the online Appendix.

We use the same calibrated monthly parameters as in Campbell and Cochrane (1999). We simulate from the model and compute for each dividend strip with a maturity of n months the average annualized excess return (risk premium), the annualized volatility, and the Sharpe ratio. The results are plotted in Figure 5 using solid lines for the first 480 months (40 years). The graph shows that the term structure of expected returns and volatilities is upward sloping, and the Sharpe ratio is upward sloping as well. The early dividend strips have a low annual average excess return equal to 1 percent.

The intuition behind these results, as provided by Lettau and Wachter (2007), can be summarized as follows. A positive dividend shock is likely to go together with a positive consumption shock due to the positive correlation between consumption and dividend growth. A positive consumption shock moves current consumption away from the habit level, which in turn lowers the effective risk aversion of the representative

¹⁴Wachter (2006) considers an extension to also match the term structure of interest rates.

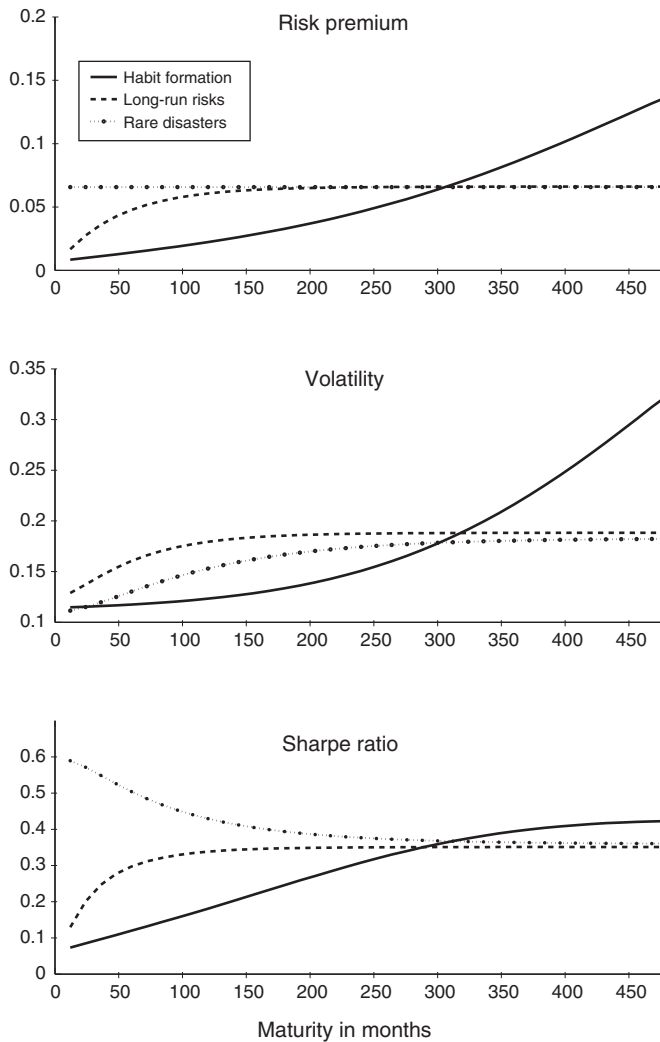


FIGURE 5. TERM STRUCTURE OF THE RISK PREMIUM, VOLATILITY, AND SHARPE RATIO FOR THE HABIT FORMATION, LONG-RUN RISKS, AND RARE DISASTERS MODEL

Notes: The graph shows the term structures of the risk premium, the volatility, and the Sharpe ratio for the Campbell and Cochrane (1999) habit formation model, the Bansal and Yaron (2004) long-run risks model, and the Gabaix (2009) rare disasters model. The graph plots the first 480 months of dividend strips, which corresponds to 40 years.

agent. The lower degree of risk aversion implies that risk premia fall and future dividends are discounted at a lower rate. As a result, prices of dividend strips increase. This effect is more pronounced for dividend strips with longer maturities, as they are more sensitive to discount rates. Since dividend prices are likely to increase in case of a positive consumption shock, they earn a positive risk premium. This effect is more pronounced for long-maturity dividend strips, explaining the upward-sloping curves for risk premia and volatilities. We find that the effect on risk premia is quantitatively stronger, which implies that Sharpe ratios also increase with maturity.

B. Long-Run Risks Model

We next consider a long-run risks model. We use the model and monthly calibration by Bansal and Yaron (2004).¹⁵ This model departs from the Lucas model in two important ways. First, the CRRA preferences are generalized to Epstein and Zin (1989) preferences to separate the coefficient of relative risk aversion from the elasticity of intertemporal substitution. Second, the dynamics of consumption and dividend growth are modified in two ways. Both growth rates have a small predictable component that is highly persistent. This implies that even though consumption risk may seem rather small over short horizons, it gradually builds up over longer horizons. In addition to the predictable component, Bansal and Yaron (2004) introduce stochastic volatility in the dynamics of consumption and dividend growth. Further details on the model can be found in the online Appendix.

We compute dividend strips in the same manner as described in the previous subsection, and we compute the average annualized excess return, volatility, and Sharpe ratio. The results are plotted in Figure 5 with dotted lines. Interestingly, the results are similar to the habit formation model. The term structure of expected returns and volatilities is upward sloping, and the Sharpe ratio is upward sloping as well.

The intuition behind these results, as also discussed by Croce, Lettau, and Ludvigson (2009), can be summarized as follows. Good states of the economy are states in which the predictable component of growth rates is high and where the stochastic volatility is low. Prices of dividends, however, increase in case of higher growth rates and fall in case of higher uncertainty. In the model, higher stochastic volatility increases discount rates, which leads to a contemporaneous decline in dividend prices. Both effects imply that dividend strips earn a positive risk premium. Long-maturity dividend strips are more sensitive to fluctuations in the predictable component of growth rates and the stochastic volatility process, which explains the upward-sloping curves for risk premia and volatilities.

C. Variable Rare Disasters Model

We then consider the variable rare disasters model by Gabaix (2009). In this model, the representative agent has CRRA preferences as in the Lucas model.¹⁶ The consumption and dividend growth process are generalized to allow for rare disasters. In case of a disaster, both consumption and dividends decline by large amounts. The probability of a rare disaster is assumed to fluctuate over time, which induces time variation in risk premia. However, since shocks to the probability of a rare disaster are independent of shocks to consumption growth, discount rate shocks do not affect risk premia, but they do affect the volatility of dividend strips. We refer to the online Appendix for further details.

The results for the variable rare disasters model are summarized in Figure 5 using dashed lines. In this model, the term structure of expected returns is flat. The reason is that strips of all maturities are exposed to the same risk in case of a disaster. Further, the return volatility is increasing with maturity. The reason is

¹⁵ We obtain comparable results by using the model and calibration by Bansal and Shaliastovich (2009).

¹⁶ See Wachter (2010) for an extension to Epstein and Zin (1989) preferences.

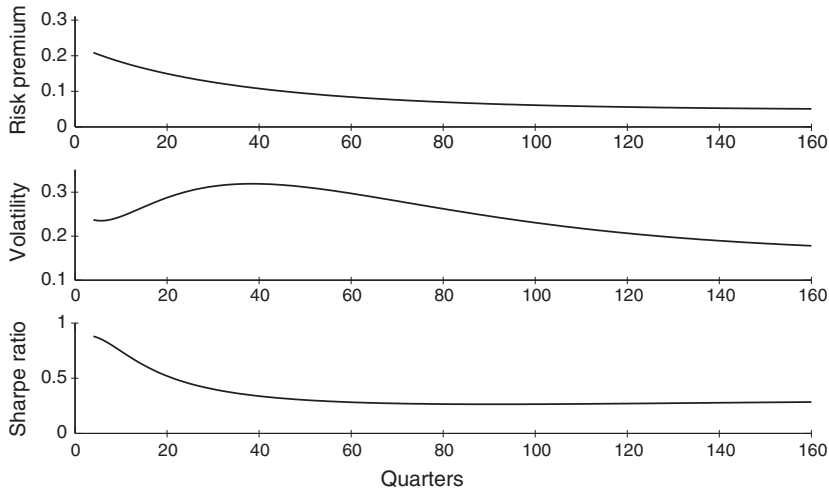


FIGURE 6. TERM STRUCTURE OF THE RISK PREMIUM, VOLATILITY, AND SHARPE RATIO FOR THE LETTAU WACHTER (2007) MODEL

Notes: The graph shows the term structures of the risk premium, the volatility, and the Sharpe ratio for the Lettau Wachter (2007) model. The graph plots the first 160 quarters of dividend strips, which corresponds to 40 years.

that longer maturity strips have a higher volatility because they are more sensitive to the time variation in disaster probabilities. As a result, the Sharpe ratio is downward sloping.

D. Lettau and Wachter (2007) Model

We finally consider the model by Lettau and Wachter (2007), which is designed to generate a downward-sloping term structure of expected returns. We use their quarterly calibration and compute dividend strips using the essentially affine structure of the model.¹⁷ For more details on the calibration and the computation of dividend strips within their model, we refer to Lettau and Wachter (2007) and the online Appendix.

We report for each dividend strip n the average annualized excess return (risk premium), the annualized volatility, and the Sharpe ratio. The results are plotted in Figure 6. The term structure for the risk premium is downward sloping, and the term structure of volatilities is initially upward sloping up until eight years, and downward sloping thereafter. The Sharpe ratio is downward sloping as well.

The model of Lettau and Wachter (2007) specifies an exogenous stochastic discount factor. Dividend growth is assumed to have a predictable component. In this model, unexpected dividend growth is priced, and the price of risk fluctuates over time. Shocks to the price of risk are assumed to be independent of the other shocks in the model. An important feature of the model is that shocks to expected and unexpected dividend growth are negatively correlated. This implies that long-maturity

¹⁷ We apply a similar method to compute the dividend strips in the long-run risk model as described in the online Appendix.

dividend claims are on a per-period basis less risky than short-horizon claims, as, for instance, a negative dividend shock today is partially offset by higher expected growth rates going forward.

The model implies a downward-sloping term structure of risk premia and Sharpe ratios. It also results in CAPM alphas of short-maturity dividend claims that are about 10 percent per annum and in CAPM betas that are below one. These aspects of the model are consistent with the properties of dividend strips that we measure directly in the data. Lettau and Wachter (2011) show how to extend the model to also fit important properties of the term structure of interest rates. However, as also pointed out by the authors, the model is not a full-fledged equilibrium model, and an important next step is to think of the micro foundations that can give rise to this specification of the technology and the stochastic discount factor.

V. Conclusion

We use data from derivatives markets to recover the prices of dividend strips on the aggregate stock market. The price of a k -year dividend strip is the present value of the dividend paid in k years. The value of the stock market is the sum of all dividend strip prices across maturities. We study the asset pricing properties of strips and find that expected returns, Sharpe ratios, and volatilities on short-term strips are higher than on the aggregate stock market, while their CAPM betas are well below one. Prices of short-term strips are more volatile than their realizations, leading to excess volatility and return predictability.

We shed new light on the composition of the equity risk premium. When decomposing the index into dividend strips, a natural question that arises is whether dividends at different horizons contribute equally to the equity risk premium or whether either short- or long-term dividends contribute proportionally more than the other. We find that short-term dividends have a higher risk premium than long-term dividends, whereas leading asset pricing models predict the opposite.

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