Is The Term Structure of Equity Risk Premia Upward Sloping?*

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Abstract

Yes! We provide a comprehensive and detailed analysis of the economic information contained in traded equity dividend strips using data from 2004-2017 for S&P 500, Nikkei 225, and Eurostoxx 50. First, we find that dividend strip returns are increasing with maturity (1 to 7 years). Second, we find that mean strip returns and strip yields are strongly upward sloping during normal times and are downward sloping during recessions. Using new data on bid-ask spreads and trade volume we document that the bid-ask spreads are large and increase with maturity. We show the bid-ask spread adjusted return also increase with maturity. In general, the dividend strip returns, particularly at shorter maturities, are below the return to the underlying asset. In totality, our empirical evidence supports the implications of leading equilibrium asset pricing models (e.g., habits, LRR).

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1 Introduction

In this paper we measure the discount rates for dividend growth implied by the yields embedded in market dividend strips. We find that (i) the yields on dividend growth rates increase with maturity, which is consistent with leading asset pricing models (ii) these discount rates are strongly rising with maturity during normal times and are declining with maturity in periods of recession. This is also consistent with leading asset pricing models, including the habit formation model of Campbell and Cochrane (1999), the long run risks model of Bansal and Yaron (2004), and versions of the rare disasters model of Reitz (1988)/Barro (2006). We compute buy and sell returns on these strips and they are increasing with maturity as well, again consistent with the models. We also show that there are important caveats to using these returns - the bid-ask spread on these contracts is larger than their monthly returns and these contracts have very low liquidity and volume compared to the futures market on the underlying equity index (e.g., S&P 500). Given the lack of liquidity we construct long horizon returns-to-maturity which mitigates the effects of large bid-ask spreads (i.e., trading costs), and find these returns and their Sharpe ratios are also rising with maturity. We conclude that the evidence from dividend strips gives strong support to the implications of leading asset pricing models.

Van Binsbergen, Brandt, and Koijen (2012), Van Binsbergen, Hueskes, Koijen, and Vrugt (2013), and Van Binsbergen and Koijen (2017) suggest that the term structure of risk premia for market dividends is *downward sloping* and is a challenging feature to leading equilibrium asset pricing models. Our data analysis differs from these papers on two fronts: (i) we incorporate information about trading costs/liquidity into our analysis which affects the measurement of realizable returns, (ii) in addition to sample averages we evaluate the behavior of the yields conditional on macroeconomic states of normal periods and recessions, which provides clearer information about the behavior of these dividend yields and its relation to the macroeconomy. This analysis of the data is important as the length of the sample is short, running from 2004 till 2017, and includes an abnormally deep recession, all of which makes measurement of unconditional mean returns difficult.

We use these new results to interpret the implications of dividend strip returns and yields for the term structure of macroeconomic risk. Although the consumption risk premium, which is not observed in the data, unconditionally rises with maturity in most leading equilibrium asset pricing models, basic economic intuition suggests, as in these models, that the term structure of equity yields is increasing on average but is downward-sloping only during severe downturns. We show that the term structure of equity risk premia in the strip data is conditionally *upward sloping in expansions*, *downward sloping in recessions*, and *unconditionally upward sloping.* The unconditional upward slope is strengthened when the frequency of recession periods in the data is adjusted to match the historical occurrence of recessions. These facts hold in each of the three major markets for which data is available, the U.S. (S&P 500), Europe (Eurostoxx 50), and Japan (Nikkei 225).

Our more comprehensive dataset also includes expanded information on asset liquidity, specifically bid-ask spreads, trading volume, and open interest information, unavailable in earlier studies. We show that asset liquidity is strongly decreasing by horizon in strip markets, measured either by trade volume or bid-ask spread. The direct impact of larger spreads at long horizons is to understate the unconditional yield and risk premium term structure slope. After accounting for bid-ask spreads, it is shown that the level of strip returns is also significantly below the total return of the index on which the contract is settled.[1] In fact, the monthly and quarterly holding returns accounting for bid/ask spreads are negative. Further, bid-ask spreads are substantially larger in Europe and Japan than in the U.S. for longer maturity contracts, and both the increase in spread by maturity and the increase in spread volatility by maturity are stronger in these regions. Both of these facts suggest that the U.S. data is closer to reflecting the variation in discount rates by horizon of interest. Longer holding period returns which minimize on transaction costs are upward sloping and are below the index. Similar patterns hold for Sharpe Ratios.

Finally, one has to be cautious about drawing quantitative implications based on data in which the average bid-ask spread is larger than the return, as is the case for the SX5E and NKY for

[1] As we have the actual bid-ask spread for each date, we compute realizable returns bought at the ask and sold at the bid and can therefore measure directly the effect on the returns within our sample.

most maturities and in the SPX for short maturities. That is, the evidence from all the countries suggests that drawing precise inference about the returns etc. is quite difficult. Bid-ask spreads rise substantially with contract maturity just as trade volume falls, which means the liquidity effect contamination particularly biases inference on the term structure slope. The spreads for futures on these indices are minuscule in comparison, and the volume traded as a fraction of open interest for index futures is orders of magnitude larger, even considering only a single contract on the Chicago Mercantile Exchange for each index. This suggests that the ability to draw inference on the economic risk of market dividends, much less consumption risk, from the strip data currently available, is somewhat limited. That said, we emphasize that the qualitative implications of the data strongly support the conditional and unconditional implications of the major models after accounting for the lack of liquidity in strip markets.

Several papers have examined the implications of the term structure of equity return risk for various models or try to provide equilibrium setup in which the term structure of divided strip returns is downward sloping. For example, Hasler and Marfe (2016) examines the implications of recession recovery for the term structure. Ai, Croce, Diercks, and Li (2017) examine the term structure of equity returns in a production-based general equilibrium economy, finding that differences in dividend exposure to shocks across the term structure can explain high short maturity risk premia, even if consumption risk does not follow this pattern. Notably, both Croce, Lettau, and Ludvigson (2015) and Belo, Collin-Dufresne, and Goldstein (2015) also find that the dividend strip and consumption strip risk premium curves need not coincide if dividend beta to consumption risk changes by horizon. Boguth, Carlson, Fisher, and Simutin (2011) and Schulz (2016) show why inference regarding dividend strips based on options data is highly questionable due to, respectively, micro-structure effects and tax issues. More generally, Hansen (2013), Backus, Boyarchenko, and Chernov (2017), and Monika, Schneider, and Tuzel (2007) study implications of various asset pricing models for different cashflow durations.

The rest of this paper follows by first introducing some basic concepts of dividend strip returns and yields. Section 3 describe basic features of our data, while Section 4 provides our empirical analysis. Section 5 provides concluding results.

2 Equity Yields

This section describes simple fundamental relations about equity prices, dividend yields, and dividend strip returns. These relations will be informative for our subsequent empirical analysis.

2.1 Equity is a Portfolio of Dividend Strips

Let S_t denote the price of a claim on all future dividends. Then, S_t can be written as

$$S_t = \sum_{n=1}^{\infty} P_{t,n}, \tag{1}$$

where $P_{t,n}$ is the price of a claim on dividend at time $t+n$, D_{t+n}. Such a claim is often called "dividend strip" or "zero-coupon equity". We can write $P_{t,n}$ as

$$P_{t,n} = \mathbb{E}_t \left[M_{t+n} D_{t+n} \right], \tag{2}$$

where M_{t+n} denotes the stochastic discount factor. The price of this claim tomorrow is $P_{t+1,n-1}$, noting that both the conditioning information and the time to maturity have changed. As a result, we can define the return on the dividend strip with time to maturity n as

$$R_{t+1,n} = \frac{P_{t+1,n-1}}{P_{t,n}}. \tag{3}$$

Note that for $n = 1$, the dividend strip return is equal to $R_{t+1,1} = \frac{D_{t+1}}{P_{t,1}}$. For maturities longer than one period, the dividend strip does not have a payout at $t+1$ and, therefore, its return only reflects the change in its price.

The price of a claim on the current dividend is the value of the dividend itself which implies $D_{t+1} = P_{t+1,0}$. Using this no-arbitrage relation, we can always write the return on the asset, R_{t+1}, in terms of its payoff as the sum of tomorrow's dividend and the value of all the future strips divided by the purchase price. Therefore, the one-period equity return can be expressed as a weighted average of dividend strip returns where the weights are given by the fraction of the corresponding dividend strip value in the total equity value:

$$R_{t+1} = \sum_{n=1}^{\infty} \frac{P_{t+1,n-1}}{S_t} = \sum_{n=1}^{\infty} \frac{P_{t,n}}{S_t} \frac{P_{t+1,n-1}}{P_{t,n}} = \sum_{n=1}^{\infty} \frac{P_{t,n}}{S_t} R_{t+1,n} = \sum_{n=1}^{\infty} \omega_{t,n} R_{t+1,n} \tag{4}$$

Where $\omega_{t,n}$ is the weight of the maturity n strip in the portfolio of all strips for the asset. This equation establishes that the asset return can be viewed as the weighted average of the strip returns, where the weights are the fraction of the value of the asset for which each strip accounts.

2.2 Relation to Dividend Futures

Dividend futures are agreements where, at time t, the buyer and the seller agree on a contract price of $F_{t,n}$ which the buyer will pay to the seller at $t+n$, and will receive the realized dividend D_{t+n} in exchange. Hence, the price is agreed upon at t while money changes hands at $t+n$.

Let $y_{t,n}$ be the time-t zero-coupon bond yield with maturity n. Then, the futures price is given by

$$F_{t,n} = P_{t,n} \exp(n y_{t,n}), \tag{5}$$

which can be alternatively written as $P_{t,n} = F_{t,n} \exp(-n y_{t,n})$. The dividend strip return then becomes the product of the change in the futures price and the return on the bond with maturity n:

$$R_{t+1,n} = \frac{F_{t+1,n-1}}{F_{t,n}} \frac{\exp(-(n-1) y_{t+1,n-1})}{\exp(-n y_{t,n})}. \tag{6}$$

Using the future price $F_{t,n}$ and current dividend D_t, it is also instructive to define the price-equity and forward equity yield for maturity n respectively as:

$$dp_{t,n} = \frac{1}{n} \log\left(\frac{D_t}{P_{t,n}}\right) \tag{7}$$

$$df_{t,n} = \frac{1}{n} \log\left(\frac{D_t}{F_{t,n}}\right) = dp_{t,n} - y_{t,n}. \tag{8}$$

2.3 Hold to Maturity Expected Returns

What is the relationship of the strip yield to the expected returns on the strip? Note that we can always rewrite the strip return to maturity as:

$$R_{t,t+n} = \frac{D_{t+n}}{P_{t,n}} = \frac{D_t}{P_{t,n}} G_{t,t+n} \tag{9}$$

Denote the n period cumulative return on an n period strip as $r_{t,t+n} = \frac{1}{n} log(R_{t,t+n}) = \frac{1}{n} log(\frac{D_{t+n}}{P_{t,n}})$ and the n period cumulative growth as $g_{t,t+n} = \frac{1}{n} log(G_{t,t+n})$. Rearranging and applying (8), we can rewrite the return decomposition as:

$$r_{t,t+n} = df_{t,n} + y_{t,n} + g_{t,t+n} \tag{10}$$

Note that $df_{t,n} + y_{t,n} = dp_{t,n}$, therefore:

$$E_t[r_{t,t+n}] = dp_{t,n} + E_t[g_{t,t+n}] \tag{11}$$

We refer to this quantity as the *hold to maturity expected return*, which is the conditional discount rate on the strip. This discount rate can be computed in the data by adding to the dp ratio the expected cumulative real growth rate as in (11). Note that $dp_{t,n}$ is an inflation neutral quantity, so using an estimate of real growth for $E_t[g_{t,t+n}]$ yields an estimate of real discount rates $E_t[r_{t,t+n}]$, which is the economic object of interest. One can also compute the premium on the hold to maturity expected return by subtracting the real yield by maturity from both sides of (11). We construct this real rate proxy by subtracting the average inflation from the yields.[2]

We can go further in characterizing the economic informational content of the dividend yields by estimating the implied conditional Sharpe Ratios. We can compute the variance of returns conditional on the time t information set:

$$V_t[r_{t,t+n}] = V_t[g_{t,t+n}] \tag{12}$$

Where the first two terms of (10) drop because they are in the time t information set. This suggests that the volatility of the contract conditional on time t information is just the expected dividend growth volatility. This allows us to write the annualized conditional Sharpe Ratio of the

[2]Given the relatively small variation of inflation rates, especially relative to the large movements in real growth and discount rates, by horizon within the recession and non-recession subsamples, it is highly unlikely that compensation for inflation risk substantively has any bearing on our measure of risk premia.

strip conditional on the time t information set as:

$$SR_{t,n} = \frac{df_{t,n} + y_{t,n} + E_t[g_{t,t+n}] - y^r_{t,n}}{V_t[g_{t,t+n}]^{0.5}} \tag{13}$$

We use the data analogues for each of these and substitute the volatiltiy of annual dividend growth over the relevant horizon for $V_t[g_{t,t+n}]$ in estimating this quantity in the data.[3]

3 Data

3.1 Dividend Futures

The data set covers the period from December 2004 to February 2017 at monthly frequency and is from a major financial institution. It contains dividend futures prices for the S&P 500, Eurostoxx 50, and Nikkei. The main data set that is used to calculate equity yields and returns correspond to LAST prices on the last trading day of the month. The maturities of dividend futures are at the end of December. At the end of the year, the buyer of the contract pays the agreed amount at the initiation of the contract (which we call "the futures price") and the contract seller pays the realized dividends of the index in the year of maturity. We infer realized dividends from index returns including and excluding distributions. E.g. at the end of July 2007, we have dividend futures prices for years until 2017. While the maximum maturity available exceeds 9 years for this particular example, the uniformly available maximum time to maturity is 7 years. The price of the S&P 500 2014 contract at the end of July 2007 is 42.4. Hence the buyer of the contract agrees to pay 42.4 at the end of 2014 to receive the dividends realized in 2014.

We also have daily BID, ASK, and LAST prices for dividend futures from Bloomberg. However, these data start later than the monthly data described above. Specifically, they start in July 2008 for Eurostoxx, in June 2010 for Nikkei, and in January 2010 for S&P 500. Daily volume and open interest are available for Eurostoxx and Nikkei for the same period as BID, ASK, and LAST prices are available.

[3] We use the conditional volatility estimates directly rather than using an analogue of (14) and (15) because the short sample does not have enough observations to estimate unconditional volatility for the longer horizons.

The data set is short (146 months) and it is more practical to analyze the behavior of fixed maturity contracts at monthly frequency. Therefore, we linearly interpolate between futures prices to obtain a finer grid of maturities. E.g. we would like to track the futures price with maturity $n = 24$ months. At the end of July 2007, however, we have contracts with maturities of 5, 17, 29, 41, ... months. To obtain a price for the 24-month contract, we linearly interpolate between $F_{t,17}$ and $F_{t,29}$, similar to the process used in Van Binsbergen, Hueskes, Koijen, and Vrugt (2013).

As can be seen from (6), the calculation of a monthly return on a 12-month dividend strip requires availability of both futures prices, as well as zero-coupon bond yields with maturities at monthly frequency. For this purpose, we use the bond yield data from Gürkaynak, Sack, and Wright (2007) available on FED's website. We obtain maturities at monthly frequency by linearly interpolating between available yields.

3.2 Dividend Growth Rates

Given the short sample, measurement of expected growth rates is difficult, therefore we provide a non-parametric approach to measuring expected growth rates. Unfortunately, even the total return indices on which these contracts are based have relatively short histories, with the exception of the S&P 500. We extend the dataset used to estimate expected growth rates by using indexes whose total return series have longer histories for the Eurostoxx and Nikkei - the Datastream EMU and Japan indices, respectively. In order to separate the data into recession and non-recession subsamples, we use the NBER recession dates for the US, the CEPR recession dates for Europe, and recession dates from a third party private provider for Japan.[4]

We model expected growth rates by sorting the data into recession and normal periods or regimes and computing multi-horizon growth rates conditional on starting in a given regime. More importantly, we use a long data history to estimate the spread between recession and non-recession real growth and inflation rates but match the recession-frequency weighted mean at

[4]The provider is the Economic Cycle Research Institute, which estimates peak-to-trough recession dates for a variety of countries. We have confirmed that the recessions dated by this provider for the US and Europe match those dated by the NBER and CEPR and that they track the cyclical behavior of GDP.

each horizon to the growth rate in the short sample for which we have strip data. Matching the unconditional mean to the short sample growth rates is essential to obtaining correctly scaled estimates of expected returns for our sample. Formally, our estimates of recession, $E_r[g_{t,t+n}]$, and normal, $E_b[g_{t,t+n}]$, expected growth rates satisfy the following, where t is in months and $t = t_s$ corresponds to December 2004 and T_s corresponds to February 2017, which we call the short sample:

$$\pi_r E_r[g_{t,t+n}] + (1 - \pi_r) E_b[g_{t,t+n}] = \sum_{t=t_s}^{T_S - 1} \frac{g_{t,t+1}}{T_S - t_s} \tag{14}$$

Where $\pi_r = \frac{\sum_{t=t_l}^{T_l-1} \mathbf{1}_{r,t}}{T_l - t_l}$ is the estimate of the recession frequency based on the long sample[5], $\mathbf{1}_{r,t}$ being an indicator for a recession at month t, $t = t_l$ corresponding to January 1950 for the S&P 500, January 1970 for the Nikkei, and January 1990 for the Eurostoxx.[6] Also based on this long sample, the spread between the recession and non-recession growth rate estimates satisfies:

$$E_r[g_{t,t+n}] - E_b[g_{t,t+n}] = \frac{\sum_{t=t_l}^{T_l-12n} \mathbf{1}_{r,t} g_{t,t+n}}{\sum_{t_l}^{T_l-12n} \mathbf{1}_{r,t}} - \frac{\sum_{t=t_l}^{T_l-12n} (1 - \mathbf{1}_{r,t}) g_{t,t+n}}{\sum_{t=t_l}^{T_l-12n} (1 - \mathbf{1}_{r,t})} \tag{15}$$

We use these two equations, (14) and (15), to estimate the conditional growth rates for the recession $E_r[g_{t,t+n}]$ and non-recession $E_b[g_{t,t+n}]$ subsamples. Therefore our estimates match the short sample mean growth rates and the long sample spread between recession and normal growth rates by horizon.

4 Results

Our primary results are based on the historical sample of equity dividend futures yields. While we present results for strip returns that are broadly consistent with the evidence from the yield

[5] The recession frequency varies substantially between the short 2005-2017 sample and the long sample for Europe. The long sample recession frequencies are 14.7% for the U.S., 15.4% for Europe, and 24.6% for Japan, while in the short sample the regions were in recession 12.2%, 22.4%, and 25.9% of the time, respectively.

[6] The longer sample starts in 1950 for the S&P 500, 1973 for the Nikkei due to data availability, and 1990 for the Eurostoxx due to the recent changes in that market. We use real growth rates for this model, however the cyclical patterns of the nominal and real growth rates are identical. Further, the nominal growth rate model for means is algebraically identical to a real growth rate model in which the regime dependence of inflation is modeled identically to the regime dependence of growth rates.

data, we also show that these results are heavily biased by the lack of liquidity in dividend strip markets.

4.1 Equity yields

We first characterize the behavior of equity yields as defined in equation (7). In each month, we compute the equity yields using futures prices and the sum of dividends over the last 12 months including the current month as D_t.

Table 1 reports summary statistics for equity yields for the S&P 500, Eurostoxx, and Nikkei. Figures 1, 2, and 3 plot the time series of equity yields in these three markets. It is self-evident that for most of the sample the U.S. term structure of equity yields is upward sloping. The ordering becomes downward sloping during the appropriately dated recessions in each region, most notably so in the Great Recession of 2008-09. Outside of the recession periods in each region, the term structure is upward sloping. Figure 4 shows that the yields slope upwards unconditionally despite the recession dominating much of the sample. Notably, the median yields suggest an even stronger upward slope in each region and strong left skewness to the short maturity yields, again driven by the recession. One cannot reject that the unconditional term structure slope is flat in any region. This evidence is consistent with the data presented in Van Binsbergen, Hueskes, Koijen, and Vrugt (2013) and Van Binsbergen and Koijen (2017).

We also present estimates of the conditional expected returns implied by these yields for each market. We stress that conditional expected returns represent the discount rates applied to dividend growth to obtain asset prices, and so are the most directly useful quantity for evaluating the economic risk of market dividends. For each region we compute the sample average of the annual growth in trailing 12 month dividends over the sample period for the equity yield data. If dividend growth is approximately iid, then these provide estimates of $E_t[g_{t,t+n}]$ as used in Equations (11). Under this assumption we compute the unconditional mean of the conditional hold to maturity expected return implied by the equity yields, expected growth, and riskfree rates using (11), reported as $E[r_{t,t+n}]$ in Table 1. The unconditional slope of the equity expected return term structure is strongly positive across regions.

We confirm the graphical evidence of pro-cyclical variation in equity term structure slope in Table 2. We split the data for each index into recession and non-recession subsamples and report the sample statistics for yields within each subsample. The dramatic differences in equity yield slope by subsample are displayed in Figures 5 and 6. Table 2 confirms that yields are strongly and statistically significantly upward sloping in non-recession periods and similarly significantly downward sloping in recessions in all three areas. This is consistent with the predictions of most major general equilibrium asset pricing models, in which the equity yield slope is expected to invert in times of temporarily high risk premia.[7] Unlike the unconditional mean evidence presented in previous research, one can strongly reject the null hypothesis that the procyclical equity term structure slope variation predicted by major asset pricing models do not hold in this dataset.

We also use our model of recession-conditional expected dividend growth to estimate the conditional risk premia. We present our estimates of real growth rates and risk premia by subsample in Table 2 alongside the resulting estimates of hold to maturity risk premia. We present the resulting unconditional means in Table 3. We find large variation in dividend growth rates by horizon based on the current economic state. In considering the magnitude of this conditional real growth rate variation relative to that of GDP we note that these indices are claims on relatively small groups of marketable firms relative to the underlying economies, firms tending to have high operational and financial leverage relative to the economy as a whole. It is intuitive, therefore, that they would follow similar cyclical patterns of growth rates to the economy as a whole but with greater variation. Based on these dividend growth rate expectations, we find that the risk premium curve is strongly upward sloping in non-recession periods and downward-sloping in crises, as displayed in Table 2.

Given the short sample, and the well understood fact that within a recession one expects a downward sloping term structure, the recession and non-recession subsamples may provide a better indication of the unconditional slope of the equity yield term structure than the sample

[7] The evidence in Table 2 regarding the variation in growth rates and risk premia suggests that variation in both cashflow and discount rates are important for the fluctuations in strip equity yields.

average. In a sample this short even one additional cycle relative to expectations could cause large divergence between the frequency of recessions in the data and the unconditional expectation of recession frequency, biasing the unconditional term structure slope estimate downwards. We can obtain a corrected estimate of the unconditional term structure slope by assuming the frequency of recessions matches the long history, 14.7%-15.4% across regions since 1970 as dated by the NBER and CEPR, rather than the much higher rates observed in this very short sample. We present these yield slope estimates and any statistics derived from them as the population statistics ("Pop") in Table 3. In Europe, where the mismatch between historical recessions and recession frequency in this data is largest at 7.1%, this correction results in a strongly unconditionally upward sloping equity yield term structure, similar to the unconditional positive slope for the S&P 500. Further, equity dividend discount rates are strongly upward sloping by horizon across regions and risk premia are strongly upward sloping for the S&P 500 and Eurostoxx and flat for the Nikkei.

Recall from (11) that when dividend growth is iid, the discount rate term structure is a level shift from the futures yield term structure. We conclude that the term structure of equity risk premia is also upward sloping based on the population mean equity yield curve slope. Using a model of conditional expected growth rates, we also conclude that the term structure of equity discount rates, the hold to maturity expected returns, is strongly upward sloping both at the sample average and population mean estimates of the yield curve slope. Finally, we find that the equity risk premium term structure is unconditionally upward sloping or flat across regions. We conclude that the equity yield curve evidence strongly supports the conditional prediction of major asset pricing models of an upward-sloping equity yield curve and risk premium curve in normal times and a downward-sloping curve in recessions and unconditionally upward-sloping equity discount rate and risk premium term structure.

4.2 Dividend Strip Returns

A second estimate of equity strip risk premia might be obtained from the historical mean returns of buying the strips and selling after a short holding period. In our sample these holding return-based estimates of the term structure weakly support a flat or upward-sloping term structure of risk premia and discount rates in all three markets. That said, we use a novel dimension of our dataset, a sample of bid and ask prices, volume traded, and open interest, to argue that these estimates are heavily contaminated by a variety of liquidity-driven pricing effects. That is, the returns of traded strips do not speak powerfully to the term structure of economic risk.

We begin by considering the monthly holding period returns on dividend strips, computed as in (6), for maturities of 1 to 7 years and presented in Table 4. For example, for the dividend strip return with a maturity of 2 years we consider the return on the claim that had a time to maturity of 24 months in the last month and 23 months in the current month. Table 4 reports the main object of interest - the term structure of equity strip returns for the S&P 500, Eurostoxx, and Nikkei. The point estimates in Table 4 show that for the S&P, Eurostoxx, and Nikkei the term structure of dividend strip returns is weakly upward sloping or flat in all three regions. Addressing the sampling issues associated with recession frequency by reweighting the recession and non-recession subsample returns by the historical recession frequency delivers an upward-sloping point estimate for all three regions, presented as the "Population" statistics in Table 4.

This evidence is also consistent with basic asset pricing models and common intuition for the shape of the term structure. The so called puzzle for returns does not exist at the point estimates of the mean returns or in the expected returns or risk premia implied by the equity yields. Both of these statistics point to an upward sloping unconditional term structure of dividend risk and a strongly procyclical slope consistent with leading equilibrium asset pricing models.

4.3 Liquidity Contamination, Strip Sharpe Ratios, and Return Levels

One potential interesting dimension of the data is whether the index is above or crosses the term structure of dividend strip returns. As explained in section 2, the index is the weighted average of dividend strip returns. Van Binsbergen and Koijen (2017) appeal to this feature to argue that if the index is below the dividend strip curve, there must be some longer maturities for which the dividend strip returns would be downward sloping. In Table 4 we show that the dividend strip returns are below the monthly index for the S&P 500 but are above the monthly index for Nikkei and Eurostoxx. However, these two markets, as shown below, are particularly illiquid and have large bid/ask spreads. After accounting for these large transaction costs the strip returns are well below the index return for all regions.

Table 4 displays the point estimates for returns and Sharpe Ratios for the S&P 500 which, as we show below, the data is most reliable, as well as for Eurostoxx and Nikkei. Even disregarding the fact that the index mean return is well within the standard errors of the strip returns at each horizon for all three markets, for example see Figure 7 for the S&P 500, we argue that there is a deeper issue in the return data for these markets driven by the illiquidity of the strips. We show below that both the Eurostoxx and Nikkei face more serious liquidity issues and more dramatic liquidity differences by horizon. We also show that while the yield evidence is broadly robust to the large liquidity effects in these markets, evidence on Sharpe Ratios and risk premium levels relative to the asset is highly biased by asset illiquidity for this data.

To estimate the magnitude of transaction costs relative to our historical return estimates, we compute the bid-ask spread as follows:

$$BA_{t,n} = \frac{F_{t,n}^{ask} - F_{t,n}^{bid}}{0.5 \cdot (F_{t,n}^{ask} + F_{t,n}^{bid})}. \tag{16}$$

Table 5 reports average bid-ask spreads for fixed maturity contracts. It is evident the bid-ask spreads are very large in all three markets and strongly increase in both mean and volatility with horizon in the Eurostoxx and Nikkei markets. Note that strongly increasing spreads and spread volatility with horizon will particularly contaminate evidence comparing the long and short end of the term structure. This is especially true where Sharpe Ratios and comparisons with much more liquid contracts are concerned. Importantly, bid-ask spread means are dramatically larger than the monthly strip returns at all horizons, and spread variance is on the same order of magnitude as return variance for most markets at all but the shortest horizons.

To reinforce the relative illiquidity of these markets we also report, for each region, the median open interest and median monthly volume traded as a fraction of the comparable statistics for the nearest to maturity index future on the same index.[8] Open interest and volume data is only available for the Eurostoxx and Nikkei dividend strip futures. Table 5 reports these results as well. Note that while the open interest is on the same order of magnitude for the near to maturity strip contracts, it is at least an order of magnitude smaller for the longer dated futures. The volume traded is one order of magnitude smaller at the short end and nearly three orders of magnitude smaller at the long end for both the Nikkei and Eurostoxx. Together these suggest that trading volume is substantially smaller in dividend futures despite having markets of similar size to the index futures at short maturities. This implies that investors trade infrequently and utilize long holding periods, consistent with our focus on hold to maturity expected returns. The open interest and volume statistics also reinforce the massive differences in liquidity by horizon in these markets, casting significant doubt on conclusions about the term structure based on statistics exposed to the strip futures' liquidity.

The illiquidity in longer dated contracts makes it difficult to justify drawing strong conclusions about the relative economic risk of dividend strips by horizon based on the monthly holding period return data. To show why, we estimate what the actual return would be if one buys the dividend strip at the ask and sells at the bid after holding periods of 1 month and 12 months.[9] This reflects the actual return accrued to an investor with that holding period. We present the results of this analysis in Table 6. Note that the bid-ask adjusted returns at the monthly horizon are negative for all three markets, and massively so for the longer maturity contracts. All of these achievable returns are well below the returns on the asset, as displayed in Figure 8. Given that transaction costs swamp the returns at short holding horizons, the marginal investor in these contracts is unlikely to evaluate the contract at these horizons and therefore the economic information about their discount rates is not reflected in the monthly return information.

Increasing the holding period to 12 months does not resolve these issues at any but the shortest maturities. The discrepancy between returns and returns net of transaction costs is still on the

[8]Chicago Mercantile Exhcange E-Mini futures for the S&P 500 and Nikkei, Eurex futures for the Eurostoxx.

[9]Note that an investor already owning or having borrowed the contract could sell it at the bid then repurchase at the ask to short sell the contract. This investor would earn the inverse of the risk premium less the impact of the transaction costs or spreads.

same order of magnitude as the mean return in all three markets, 3% for the S&P, 6% for the Eurostox, and 7% for the Nikkei at the long end. For longer maturity contracts it is still difficult to justify the assumption that the marginal investor intends to give up as much as 75% of the return on the contract by trading it at a 1 year horizon.

To resolve the issue of spread adjustments we consider the outcomes of investors that intend to hold the contract to maturity. These investors would buy the contract at the ask price then receive the dividend growth at maturity. This strategy accurately reflects the returns achievable by investors while mitigating the impact of transaction costs. We report the hold to maturity expected returns, computed as in (11), averaged over the sample with bid-ask data using the purchase price as the last price and the ask price in the last two lines of each panel of Table 6. The expected returns have the least liquidity contamination and most directly reflect the discount rates used by investors since they are conditional expected returns. These expected returns are both strongly upward sloping by horizon and well below the asset returns over the same sample in all three markets. They also reflect the same qualitative and quantitative patterns as the expected returns unadjusted for transaction costs.[10] This suggests that the economic information contained in the strip yields, which strongly supports the leading asset pricing models, is substantially more robust to the liquidity issues in these markets than is the short horizon return-based evidence.

Finally, we directly address the slope of the strip Sharpe Ratios by horizon. Due to the heavy liquidity contamination of the data for short holding horizons and the large variation in bid-ask spread volatility by horizon, we present only the least contaminated data which is the conditional expected hold to maturity Sharpe Ratio as estimated in (13). While having the downside of requiring an assumption about expected growth rates and expected growth volatility, these Sharpe Ratios have the benefit of directly reflecting the risk compensation demanded by investors, which is the quantity of interest for the term structure of risk. We present the population mean conditional Sharpe Ratio in Table 7. This statistic is a weighted average of the recession and non-recession

[10]The 7 year contract for the Eurostoxx market does not reflect this pattern, however this is entirely due to a rapid decline in the yields of the long dated contracts in the last year of the sample window. Aside from highlighting the pitfalls of a short dataset, this is straightforward to justify as anticipation of major macroeconomic events in the region with a known timeline, e.g. Brexit.

conditional Sharpe Ratios, weighted by the historical recession frequency. This is an estimate of the average conditional Sharpe Ratio, not the unconditional Sharpe Ratio. These Sharpe ratios are strongly upward sloping by horizon for the S&P 500 and Nikkei, and flat or weakly upward sloping for the Eurostoxx.

Once we have corrected for the dramatic illiquidity of the dividend futures markets and the substantial variation in liquidity by horizon, the data continue to provide strong support for the predictions of major asset pricing models of short horizon dividend claims carrying less macroeconomic risk than long horizon claims. There is little evidence to support the claim that the economic risk of the index is below that of the short maturity claims and no evidence to support declining risk compensation measured by Sharpe Ratio by horizon. Short holding period return estimates are so heavily contaminated by spread and spread volatility that it is difficult to justify drawing economic conclusions about dividend risk, as opposed to microstructure and trading risk, from these realized returns.

5 Conclusion

Using additional asset prices to learn about risk and reward in financial markets is a welcomed endeavor. At the same time as more esoteric markets are analyzed any inference has to be judicious and with an eye to institutional features of such markets. Recently, several papers suggest that the term structure of dividend strip returns is downward sloping and thus poses a challenge to existing asset pricing models. In this paper we show the data clearly demonstrate that the term structure of dividend strip risk premia and discount rates implied by equity strip yields is upward sloping unconditionally, downward sloping in crises, and upward sloping in non-recession periods. All three predictions are consistent with leading asset pricing models. We show that the point estimates of the risk premium curves derived from realized returns also support these models. Despite this, we also show that attempts to elicit additional information from short horizon holding returns, Sharpe Ratios, and comparisons between strip returns and returns on the asset are heavily contaminated by the dramatic illiquidity of strip markets. Using the most reasonable adjustments for transaction costs and the most liquidity robust statistics, we find that the asset returns are above the short maturity strip returns and that the strip Sharpe Ratios are upward sloping by maturity. In all, we find considerable support for, and no reliable evidence against, the predictions of leading asset pricing models for the term structure of risk premia in the best available data on equity dividend strips.

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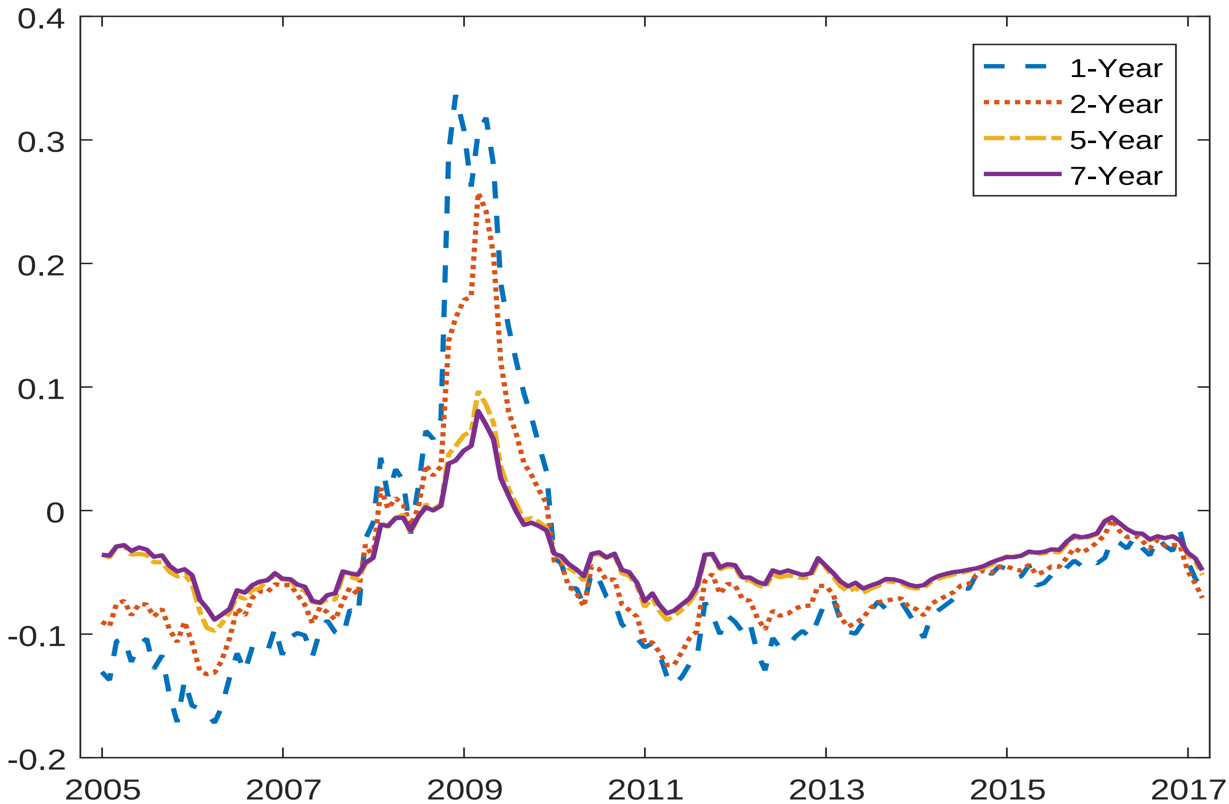
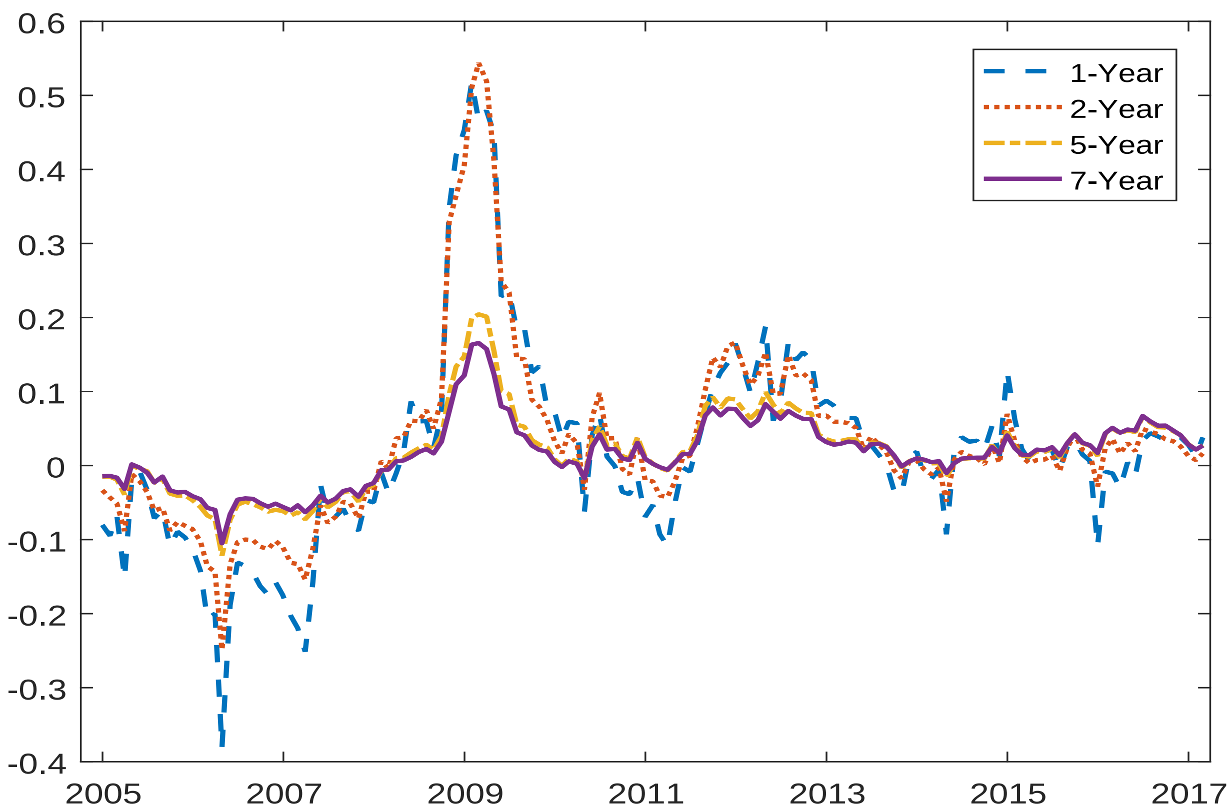
Figure 1: Equity yields: S&P 500



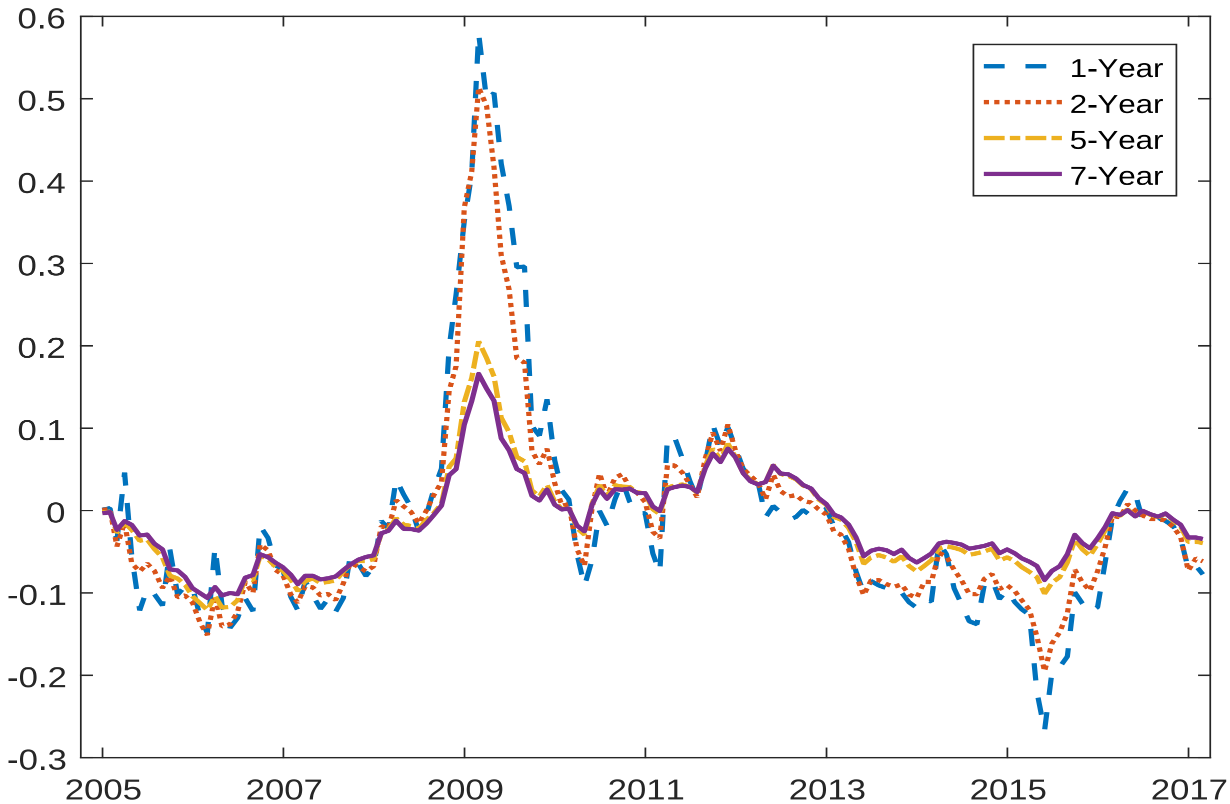
Notes: The figure plots the time series of equity yields from December 2004 to July 2015 inferred from S&P 500 dividend futures contracts for four maturities. The series are constructed as described in Section 4.1. Equity yields are $df_{t,n} = \frac{1}{n} \log \left(\frac{D_t}{F_{t,n}} \right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend.

Figure 2: Equity yields: Eurostoxx 50



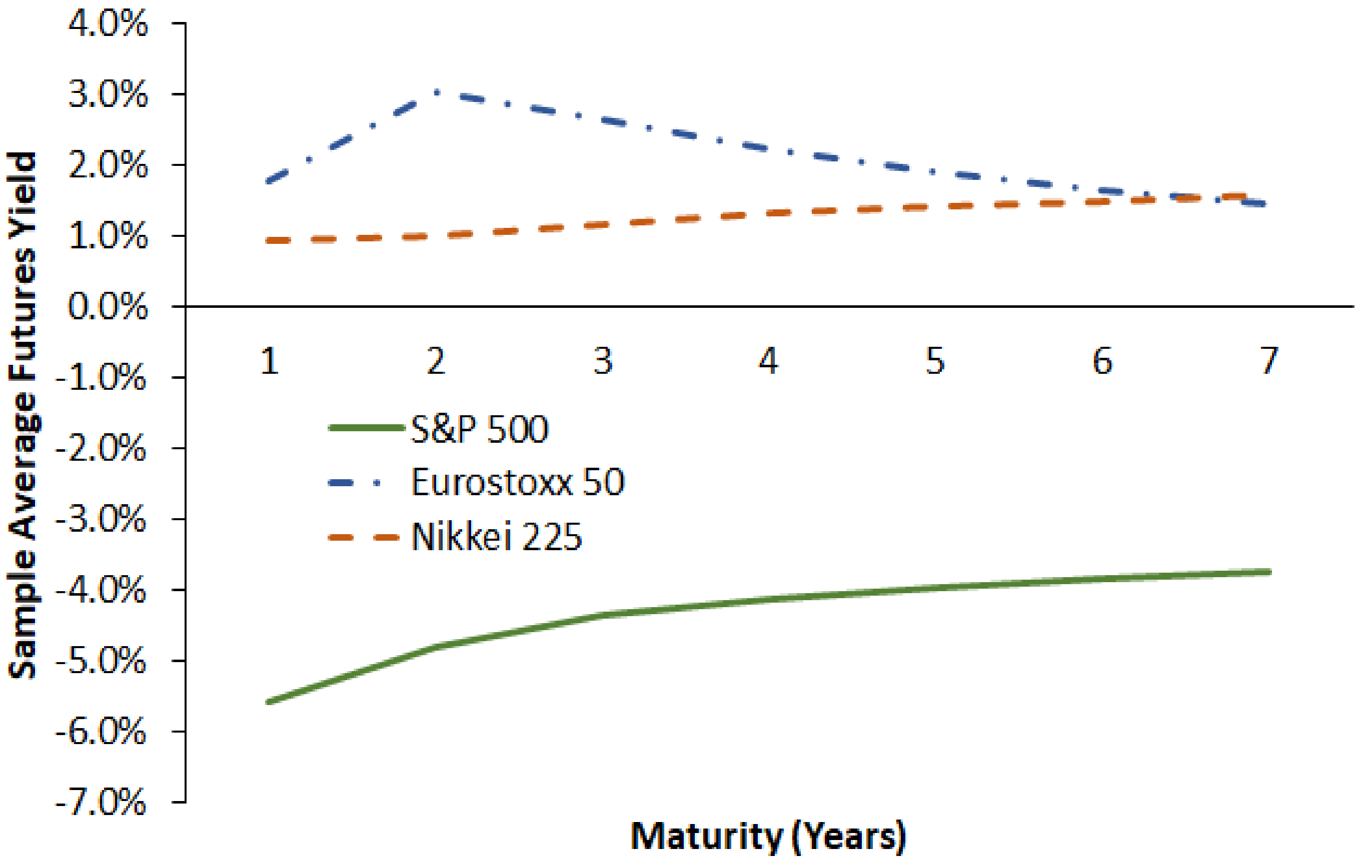
Notes: The figure plots the time series of equity yields from December 2004 to July 2015 inferred from Eurostoxx 50 dividend futures contracts for four maturities. The series are constructed as described in Section 4.1. Equity yields are $df_{t,n} = \frac{1}{n} \log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend.

Figure 3: Equity yields: Nikkei 225



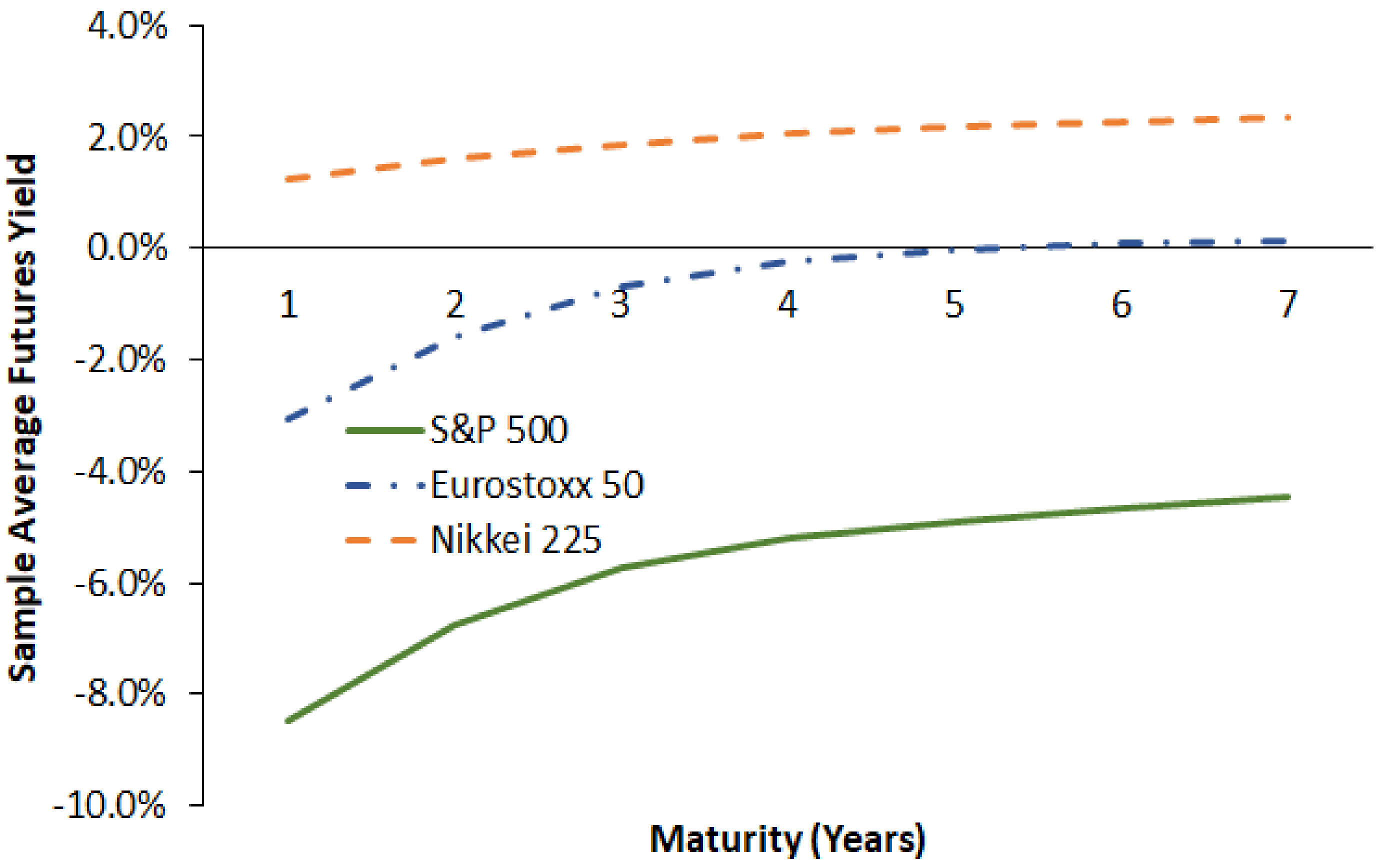
Notes: The figure plots the time series of equity yields from December 2004 to July 2015 inferred from Nikkei 225 dividend futures contracts for four maturities. The series are constructed as described in Section 4.1. Equity yields are $df_{t,n} = \frac{1}{n}\log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend.

Figure 4: Term Structure of Equity Strip Yields



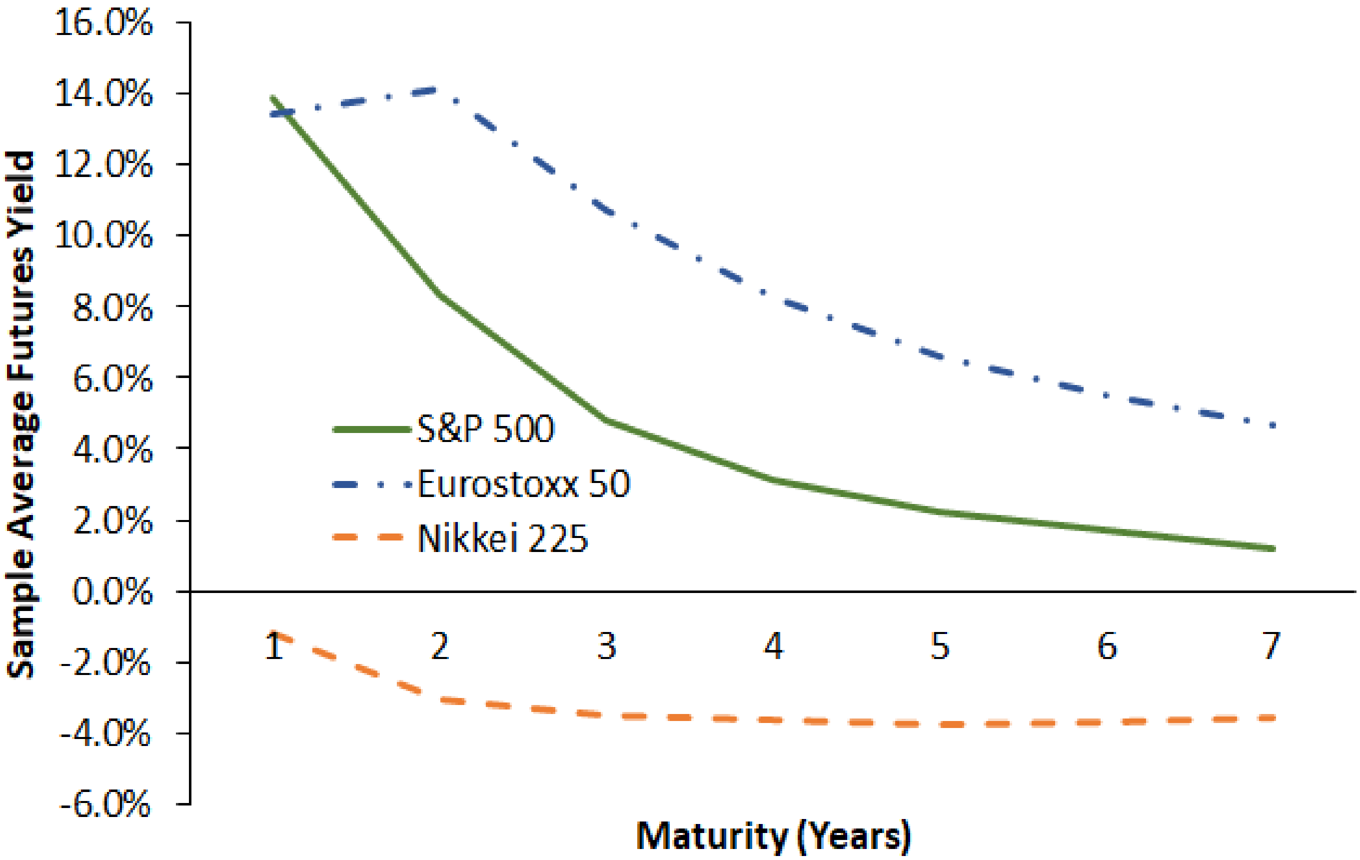
Notes: The figure plots the sample mean of equity yields from December 2004 to July 2015 inferred from dividend futures contracts on each index. The series are constructed as described in Section 4.1. Equity yields are $df_{t,n} = \frac{1}{n} \log \left(\frac{D_t}{F_{t,n}} \right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend.

Figure 5: Term Structure of Equity Strip Yields Excluding Recession



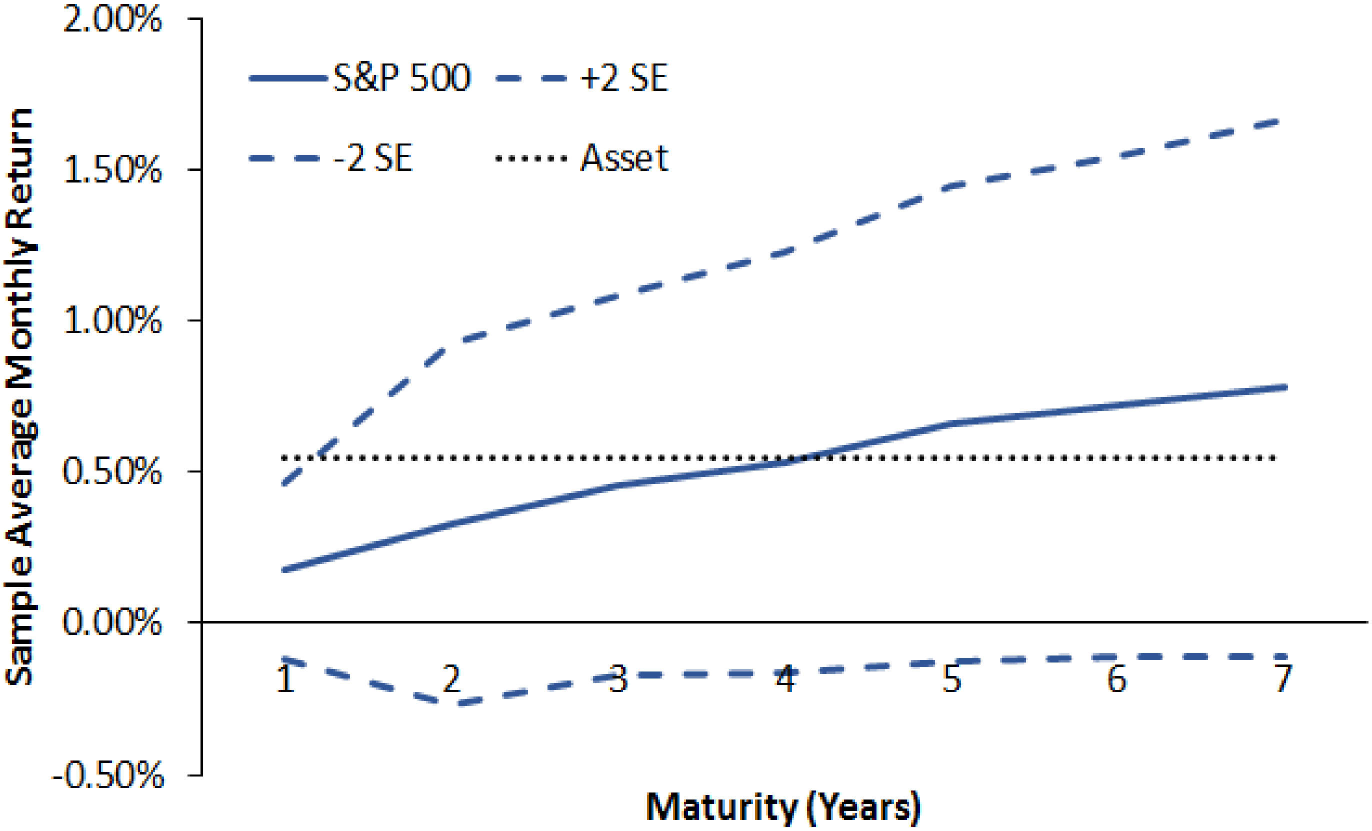
Notes: Equity yields are calculated as described in Section 4.1. Non-recession results are reported for the period from December 2004 to February 2017 excluding the period from December 2007 to June 2009 which corresponds to the Great Recession dated by NBER. For the Eurostoxx 50 results also exclude April 2011 to March 2013, the dates assigned to the Euro Recession Recession. Equity yields are $df_{t,n} = \frac{1}{n} \log \left(\frac{D_t}{F_{t,n}} \right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend.

Figure 6: Term Structure of Equity Strip Yields Recession Only



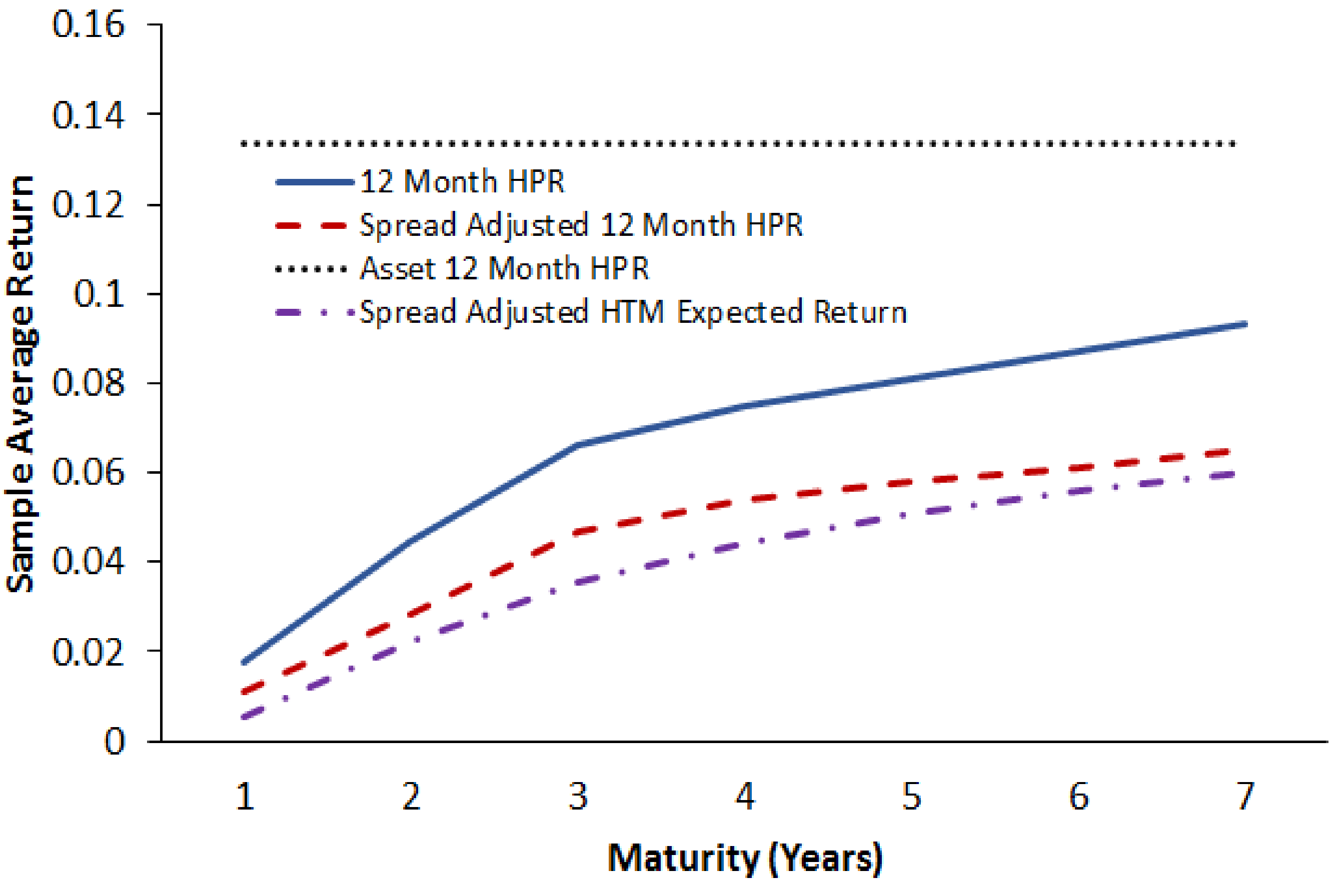
Notes: Equity yields are calculated as described in Section 4.1. Recession results are reported for the period from December 2007 to June 2009 which corresponds to the Great Recession dated by NBER. For the Eurostoxx 50 results also include April 2011 to March 2013, the dates assigned to the Euro Recession Recession. Equity yields are $df_{t,n} = \frac{1}{n} \log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend.

Figure 7: Term Structure of Equity Strip Monthly Returns with Standard Error



Notes: Dividend strip returns are calculated as described in Section 4.2 using (6) $R_{t+1,n} = \frac{F_{t+1,n-1}}{F_{t,n}} \frac{\exp(-(n-1)y_{t+1,n-1})}{\exp(-ny_{t,n})}$ with $F_{t,n}$ the futures price for maturity n and $y_{t,n}$ the risk free zero coupon bond yield for maturity n. Means and standard deviations are monthly. Results are reported for the period from January 2005 to February 2017. The asset is the monthly total return on the index used to settle the contract. t-statistics are based on Newey-West standard errors. Maturities are in annual units.

Figure 8: S&P 500 Strip Holding Period Return and Hold to Maturity Return



Notes: The period starts in January 2010 for S&P 500 and for Eurostoxx 50, and June 2010 for Nikkei 225, and ends in February 2017 for all. The asset is the monthly total return on the index used to settle the contract. Dividend strip returns are computed as in (6) and spread adjusted dividend strip returns correspond to

$$R_{t+k,h} = \left(\frac{F^{bid}_{t+k,n-k}}{F^{ask}_{t,n}} \frac{\exp(-(n-k)y_{t+k,n-k})}{\exp(-ny_{t,n})} \right)^{1/k} - 1,$$

where results are reported for maturities $n = 1, ..., 7$ years, and holding periods of $k = 1$ *and* 12 months. $E_t[r_{t,t+n}]$ is the hold to maturity expected return computed as in (11) under the assumption of iid expected dividend growth, $E_t[r_{t,t+n}] = df_{t,n} + y_{t,n} + E_t[g_{t,t+n}]$. $E_t[r_{t,t+n}]$ (Ask) is the same statistic computed using the ask futures price to compute $df_{t,n}$. Maturities are in annual units.

Table 1: Equity Yields df_n

Panel A: S&P 500								
n	1	2	3	4	5	6	7	7 - 1
Sample Average	-5.581	-4.801	-4.356	-4.133	-3.979	-3.840	-3.729	1.852
t-statistic	-2.180	-2.800	-3.630	-4.240	-4.690	-5.080	-5.490	0.950
Standard Deviation	9.899	6.760	4.730	3.844	3.356	2.982	2.687	7.558
Median	-8.179	-6.490	-5.732	-4.989	-4.725	-4.498	-4.346	3.187
$E[r_{t,t+n}]$	1.171	2.134	2.814	3.281	3.683	4.030	4.350	3.179
Panel B: Eurostoxx 50								
n	1	2	3	4	5	6	7	7 - 1
Sample Average	1.777	3.031	2.645	2.236	1.905	1.658	1.452	-0.325
t-statistic	0.540	1.040	1.250	1.370	1.420	1.440	1.440	-0.130
Standard Deviation	13.488	11.991	8.561	6.564	5.359	4.552	3.981	10.085
Median	1.271	1.592	1.980	2.030	1.784	1.624	1.534	0.990
$E[r_{t,t+n}]$	4.711	6.058	5.810	5.582	5.399	5.312	5.265	0.554
Panel C: Nikkei 225								
n	1	2	3	4	5	6	7	7 - 1
Sample Average	-1.437	-1.454	-1.843	-1.842	-1.727	-1.579	-1.418	0.019
t-statistic	-0.430	-0.510	-0.830	-1.010	-1.100	-1.150	-1.180	0.010
Standard Deviation	13.613	11.709	8.891	7.213	6.110	5.302	4.643	10.030
Median	-3.688	-4.062	-3.306	-2.571	-2.235	-2.205	-2.266	2.445
$E[r_{t,t+n}]$	8.424	8.472	8.165	8.260	8.465	8.711	8.970	0.546

Notes: Equity yields are calculated as described in Section 4.1. Results are reported for the period from December 2004 to February 2017. The time series of equity yields is formed from $df_{t,n} = \frac{1}{n}\log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend. Hold to maturity expected returns are $E[r_{t,t+n}] = df_n + y_n + E[g_{t,t+n}]$, where $E[g_{t,t+n}]$ is the sample mean real growth rate and y_n is the yield on a zero coupon bond with maturity n. t-statistics are based on Newey-West standard errors. Maturities are in annual units.

Table 2: Equity Yields $df_{t,n}$ - Recession and Normal Subsamples

Panel A: S&P 500								
Normal	1	2	3	4	5	6	7	7-1
Sample Average	-8.470	-6.752	-5.715	-5.211	-4.903	-4.660	-4.463	4.008
t-statistic	-7.190	-8.850	-10.100	-9.940	-10.160	-10.490	-10.900	4.350
Standard Deviation	4.773	3.252	2.445	2.200	2.029	1.848	1.694	3.723
$E_t[g_{t,t+n}]$	6.303	5.988	5.593	5.386	5.320	5.242	5.147	-1.155
$E_t[rx_{t,t+n}]$	-0.136	1.298	1.930	2.204	2.428	2.580	2.686	2.822
Recession	1	2	3	4	5	6	7	7-1
Sample Average	13.882	8.336	4.799	3.130	2.245	1.688	1.214	-12.669
t-statistic	2.330	1.940	1.710	1.480	1.250	1.120	0.910	-2.740
Standard Deviation	13.223	9.316	6.143	4.667	3.919	3.316	2.953	10.484
$E_t[g_{t,t+n}]$	-0.535	1.294	3.593	4.799	5.182	5.639	6.188	6.723
$E_t[rx_{t,t+n}]$	15.246	11.361	10.182	9.847	9.450	9.418	9.478	-5.769
Panel B: Eurostoxx 50								
Normal	1	2	3	4	5	6	7	7-1
Sample Average	-3.048	-1.574	-0.706	-0.253	-0.047	0.074	0.129	3.178
t-statistic	-1.240	-0.850	-0.470	-0.190	-0.040	0.070	0.130	1.880
Standard Deviation	9.146	6.528	5.169	4.403	3.896	3.533	3.239	6.723
$E_t[g_{t,t+n}]$	4.032	3.629	3.071	3.009	3.047	2.830	2.819	-1.213
$E_t[rx_{t,t+n}]$	3.028	4.115	4.466	4.852	4.985	4.928	5.000	1.972
Recession	1	2	3	4	5	6	7	7-1
Sample Average	13.449	14.169	10.749	8.254	6.626	5.490	4.651	-8.798
t-statistic	3.290	3.410	4.000	4.270	4.420	4.510	4.490	-2.690
Standard Deviation	15.172	14.689	9.707	7.059	5.509	4.489	3.818	11.784
$E_t[g_{t,t+n}]$	-10.978	-8.757	-5.689	-5.348	-5.557	-4.358	-4.298	6.681
$E_t[rx_{t,t+n}]$	4.864	7.718	7.145	5.019	3.790	3.633	2.704	-2.160
Panel C: Nikkei 225								
Normal	1	2	3	4	5	6	7	7-1
Sample Average	-3.693	-3.779	-3.783	-3.463	-3.118	-2.789	-2.472	1.221
t-statistic	-1.320	-1.640	-1.950	-2.060	-2.100	-2.110	-2.100	0.610
Standard Deviation	11.806	9.410	7.504	6.329	5.486	4.831	4.264	8.657
$E_t[g_{t,t+n}]$	10.291	10.914	10.813	10.351	10.187	10.121	9.981	-0.311
$E_t[rx_{t,t+n}]$	6.231	6.882	6.802	6.714	6.951	7.229	7.418	1.186
Recession	1	2	3	4	5	6	7	7-1
Sample Average	5.035	5.213	3.723	2.808	2.264	1.891	1.605	-3.431
t-statistic	0.980	1.130	1.160	1.190	1.220	1.220	1.200	-0.830
Standard Deviation	16.321	14.864	10.230	7.643	6.116	5.111	4.398	12.717
$E_t[g_{t,t+n}]$	7.831	5.918	6.230	7.650	8.152	8.354	8.786	0.955
$E_t[rx_{t,t+n}]$	14.928	12.844	11.586	11.923	11.712	11.498	11.604	-3.323

Notes: Equity yields are calculated as described in Section 4.1. Non-recession results are reported for the period from December 2004 to February 2017 excluding the period from December 2007 to June 2009 which corresponds to the Great Recession dated by NBER. For the Eurostoxx 50 results also exclude April 2011 to March 2013, the dates assigned to the Euro Recession Recession. Equity yields are $df_{t,n} = \frac{1}{n}\log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend. Risk premia are computed as $E_t[rx_{t,t+n}] = df_{t,n} + y_{t,n} + E_t[g_{t,t+n}] - y^r_{t,n}$, where the subsample $E_t[g_{t,t+n}]$ is computed using (14) and (15) and matches the unconditional mean for the 2005 to present sample and the recession-non-recession spread for that horizon for a longer sample, 1950 to present for the S&P 500, 1970 to present for the Datastream Japan index and 1990 to present for the EMU index. t-statistics are based on Newey-West standard errors. Maturities are in annual units.

Table 3: Population Yields and Expected Returns

Panel A: S&P 500								
n	1	2	3	4	5	6	7	7 - 1
$E[df_{t,n}]$ (Pop.)	-5.192	-4.539	-4.173	-3.988	-3.855	-3.729	-3.630	1.562
$E[g_{t,t+n}]$ (Pop.)	5.300	5.300	5.300	5.300	5.300	5.300	5.300	0.000
$E[r_{t,t+n}]$ (Pop.)	1.559	2.397	2.999	3.430	3.813	4.146	4.455	2.896
$E[rx_{t,t+n}]$ (Pop.)	2.120	2.773	3.140	3.325	3.458	3.583	3.682	1.562
Panel B: Eurostoxx 50								
n	1	2	3	4	5	6	7	7 - 1
$E[df_{t,n}]$ (Pop.)	-0.513	0.846	1.055	1.055	0.979	0.906	0.824	1.337
$E[g_{t,t+n}]$ (Pop.)	1.725	1.725	1.725	1.725	1.725	1.725	1.725	0.000
$E[r_{t,t+n}]$ (Pop.)	2.385	3.840	4.184	4.357	4.428	4.508	4.578	2.193
$E[rx_{t,t+n}]$ (Pop.)	3.310	4.669	4.878	4.878	4.802	4.729	4.647	1.337
Panel C: Nikkei 225								
n	1	2	3	4	5	6	7	7 - 1
$E[df_{t,n}]$ (Pop.)	-1.549	-1.570	-1.940	-1.923	-1.796	-1.639	-1.471	0.079
$E[g_{t,t+n}]$ (Pop.)	9.687	9.687	9.687	9.687	9.687	9.687	9.687	0.000
$E[r_{t,t+n}]$ (Pop.)	8.309	8.355	8.067	8.179	8.395	8.650	8.917	0.608
$E[rx_{t,t+n}]$ (Pop.)	8.367	8.346	7.977	7.993	8.120	8.277	8.446	0.079

Notes: Equity yields are calculated as described in Section 4.1. Non-recession results are reported for the period from December 2004 to February 2017 excluding the period from December 2007 to June 2009 which corresponds to the Great Recession dated by NBER. For the Eurostoxx 50 results also exclude April 2011 to March 2013, the dates assigned to the Euro Recession Recession. The time series of equity yields is formed from $df_{t,n} = \frac{1}{n}\log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend. Risk premia are computed as $E_t[rx_{t,t+n}] = df_{t,n} + y_{t,n} + E_t[g_{t,t+n}] - y^r_{t,n}$, where the subsample $E_t[g_{t,t+n}]$ is computed using (14) and (15) and matches the unconditional mean for the 2005 to present sample and the recession-non-recession spread for that horizon for a longer sample, 1950, 1970, or 1990 to present for the S&P 500, Nikkei 225, or Eurostoxx 50, respectively. Population values re-weight the recession and non-recession subsamples by the historical recession frequency. Maturities are in annual units.

Table 4: Dividend Strip Returns

Maturity	1	2	3	4	5	6	7	7-1	Asset
Panel A: S&P 500									
Sample Average	2.071	3.944	5.493	6.370	7.908	8.641	9.337	7.266	6.579
t-statistic	1.190	1.100	1.460	1.520	1.680	1.740	1.760	1.720	0.000
Standard Deviation	7.055	11.082	11.626	12.877	14.124	15.031	15.874	12.735	14.096
Sharpe Ratio	0.399	0.423	0.537	0.552	0.613	0.624	0.635	0.571	0.380
Mean (Pop.)	2.024	3.589	5.139	5.989	7.465	8.162	8.815	6.791	5.956
Sharpe Ratio (Pop.)	0.369	0.369	0.484	0.503	0.561	0.572	0.581	0.518	0.462
Panel B: Eurostoxx 50									
Sample Average	6.626	7.494	6.570	6.369	6.526	6.372	6.432	-0.194	5.742
t-statistic	2.350	1.190	0.900	0.860	0.890	0.880	0.870	-0.040	0.000
Standard Deviation	9.623	19.565	21.840	22.104	22.002	21.639	21.675	17.376	17.035
Sharpe Ratio	0.907	0.491	0.397	0.383	0.392	0.392	0.394	0.225	0.336
Mean (Pop.)	7.808	11.307	11.726	11.746	11.856	11.496	11.578	3.769	5.373
Sharpe Ratio (Pop.)	1.218	0.783	0.700	0.680	0.685	0.675	0.674	0.286	0.311
Panel C: Nikkei 225									
Sample Average	10.997	11.641	13.512	15.454	16.610	17.665	18.575	7.578	6.994
t-statistic	2.470	1.510	1.550	1.650	1.680	1.730	1.790	1.070	0.000
Standard Deviation	10.804	20.121	22.988	23.703	24.210	24.588	25.054	19.271	19.678
Sharpe Ratio	1.033	0.587	0.595	0.659	0.693	0.725	0.748	0.202	0.351
Mean (Pop.)	11.311	12.243	14.156	16.117	17.274	18.328	19.244	7.933	3.744
Sharpe Ratio (Pop.)	1.064	0.619	0.624	0.688	0.721	0.753	0.775	0.400	0.194

Notes: The time series of dividend strip returns is calculated as described in Section 4.2 using (6) $R_{t+1,n} = \frac{F_{t+1,n-1}}{F_{t,n}} \frac{\exp(-(n-1)y_{t+1,n-1})}{\exp(-ny_{t,n})}$ with $F_{t,n}$ the futures price for maturity n and $y_{t,n}$ the risk free zero coupon bond yield for maturity n. Means and standard deviations are monthly. Results are reported for the period from January 2005 to February 2017. Population statistics re-weight the recession and non-recession subsamples by the historical recession frequency. The asset is the monthly total return on the index used to settle the contract. t-statistics are based on Newey-West standard errors. Maturities are in annual units.

Table 5: Bid-Ask Spreads and Strip Liquidity

Panel A: S&P 500								
Maturity	1	2	3	4	5	6	7	Asset
Sample Average	15.731	19.147	21.381	24.693	27.096	29.442	31.182	0.457
Standard Deviation	1.991	2.355	2.556	2.654	2.917	3.177	3.150	0.159
Median Open Interest	-	-	-	-	-	-	-	$2815{*}10^3$
Median Volume	-	-	-	-	-	-	-	$3338{*}10^4$

Panel B: Eurostoxx 50								
Maturity	1	2	3	4	5	6	7	Asset
Sample Average	4.286	8.653	14.709	28.790	43.478	62.733	69.167	0.505
Standard Deviation	1.137	2.521	4.299	10.119	17.793	21.185	20.031	0.062
Median Open Interest	62.222	54.931	85.614	24.608	16.131	10.690	6.077	$2883{*}10^3$
Median Volume	5.218	6.165	19.801	2.713	1.517	0.740	0.327	$2020{*}10^4$

Panel C: Nikkei 225								
Maturity	1	2	3	4	5	6	7	Asset
Sample Average	17.074	28.662	35.720	40.894	55.537	63.531	68.160	7.493
Standard Deviation	3.445	7.001	8.174	7.484	8.562	9.425	9.670	3.375
Median Open Interest	250.553	154.358	107.581	74.258	46.785	21.927	9.595	$2254{*}10^6$
Median Volume	9.127	7.114	3.163	1.648	0.624	0.131	0.031	$1315{*}10^7$

Notes: The time series of bid-ask spreads for dividend futures is calculated as in (16) $BA_{t,n} = \frac{F^{ask}_{t,n} - F^{bid}_{t,n}}{0.5 \cdot (F^{ask}_{t,n} + F^{bid}_{t,n})}$ with $F^{ask}_{t,n}$ the dividend futures ask price for maturity n and $F^{bid}_{t,n}$ the bid. Spreads are presented in annualized percentages (multiplied by 1200). Median volume and open interest for each maturity are the median of the monthly fraction of the index futures market's value for the same statistic, expressed as percentages. Results are reported using monthly data. The period starts in January 2010 for S&P 500 and for Eurostoxx 50, and June 2010 for Nikkei 225, and ends in February 2017 for all. The asset or index is the nearest to maturity Chicago Mercantile Exchange futures contract on the same index in local currency (Eurex for the Eurostoxx 50).Maturities are in annual units.

Table 6: Dividend Strip Returns: Buy at Ask, Sell at Bid

Maturity	1	2	3	4	5	6	7	Asset
Panel A: S&P 500								
1 Month	2.601	6.369	8.352	9.291	9.995	10.841	11.490	11.739
1 Month Spread Adj.	-12.817	-12.788	-13.001	-15.300	-16.768	-18.379	-19.300	
$E[r_{t,t+n}]$	1.099	2.620	3.862	4.713	5.326	5.793	6.199	
$E[r_{t,t+n}]$ (Ask)	0.511	2.248	3.549	4.440	5.103	5.594	6.025	
Panel B: Eurostoxx 50								
1 Month	3.879	4.938	5.128	4.311	4.289	4.009	3.772	6.394
1 Month Spread Adj.	-0.561	-3.599	-8.783	-23.160	-37.529	-54.529	-62.664	
$E_t[r_{t,t+n}]$	1.602	2.342	2.546	2.522	2.413	2.340	2.261	
$E_t[r_{t,t+n}]$ (Ask)	1.434	2.107	2.322	2.287	2.061	1.757	-0.485	
Panel C: Nikkei 225								
1 Month	8.616	12.888	16.597	19.079	20.450	21.387	21.770	7.628
1 Month Spread Adj.	-7.853	-15.505	-18.841	-21.163	-34.048	-41.366	-45.309	
$E_t[r_{t,t+n}]$	6.150	7.196	7.938	8.600	9.110	9.536	9.848	
$E_t[r_{t,t+n}]$ (Ask)	5.389	6.580	7.359	8.067	8.526	8.970	9.319	

Notes: The period starts in January 2010 for S&P 500 and for Eurostoxx 50, and June 2010 for Nikkei 225, and ends in February 2017 for all. The asset is the monthly total return on the index used to settle the contract. Dividend strip returns are computed as in (6) and spread adjusted dividend strip returns correspond to

$$R_{t+k,h} = \left(\frac{F^{bid}_{t+k,n-k}}{F^{ask}_{t,n}} \frac{\exp(-(n-k)y_{t+k,n-k})}{\exp(-ny_{t,n})} \right)^{1/k} - 1,$$

where results are reported for maturities $n = 1, ..., 7$ years, and holding periods of $k = 1$ *and* 12 months. $E[r_{t,t+n}]$ is the hold to maturity expected return computed as in (11), $E[r_{t,t+n}] = df_n + y_n + E[g_{t,t+n}]$. $E[r_{t,t+n}]$ (Ask) is the same statistic computed using the ask futures price to compute df_n. $E[g_{t,t+n}]$ is the one year growth rate for the 2010 on subsample for all horizons. Maturities are in annual units.

Table 7: Sharpe Ratios

Maturity	1	2	3	4	5	6	7
Panel A: S&P 500							
$SR_{t,n}$ (Pop.)	0.314	0.360	0.420	0.442	0.510	0.529	0.610
Panel B: Eurostoxx 50							
$SR_{t,n}$ (Pop.)	0.338	0.410	0.435	0.405	0.395	0.361	0.356
Panel C: Nikkei 225							
$SR_{t,n}$ (Pop.)	0.635	0.649	0.671	0.666	0.727	0.743	0.783

Notes: $SR_{t,n}$ is the hold to maturity conditional annualized Sharpe Ratio computed as in (13), $SR_{t,n} = \frac{df_{t,n}+y_{t,n}+E_t[g_{t,t+n}]-y^r_{t,n}}{V_t[g_{t,t+n}]^{0.5}}$. Non-recession results are reported for the period from December 2004 to February 2017 excluding the period from December 2007 to June 2009 which corresponds to the Great Recession dated by NBER. For the Eurostoxx 50 results also exclude April 2011 to March 2013, the dates assigned to the Euro Recession Recession. Equity yields are $df_{t,n} = \frac{1}{n}\log\left(\frac{D_t}{F_{t,n}}\right)$, with $F_{t,n}$ the futures price and D_t the trailing 12 month dividend. The subsample $E_t[g_{t,t+n}]$ matches the unconditional mean for the 2005 to present sample and the recession-non-recession spread for that horizon for a longer sample, 1950, 1970, or 1990 to present for the S&P 500, Nikkei 225, or Eurostoxx 50, respectively. The subsample $V_t[g_{t,t+n}]$ matches the volatility of growth rates for the same periods. Population values re-weight the recession and non-recession subsamples by the historical recession frequency, and therefore estimate the unconditional mean of the conditional Sharpe Ratio, not the unconditional Sharpe Ratio. Maturities are in annual units.