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Abstract

We study a new data set of dividend derivatives with maturities up to 10 years across three world regions: the US, Europe, and Japan. We use these asset prices to construct equity yields, analogous to bond yields. We decompose the equity yields to obtain a term structure of expected dividend growth rates and a term structure of risk premia, which decomposes the equity risk premium by maturity. We find that the slope of the term structure of risk premia is pro-cyclical, whereas the slope of the term structure of expected dividend growth rates is counter-cyclical. The comovement of yields across regions is on average higher for long-maturity yields than for short-maturity yields, whereas the variation in this comovement is much higher for short-maturity yields.

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There exists a large literature studying fluctuations of, and the information contained in, the term structures of nominal and real interest rates.[1] At each point in time, these term structures summarize pricing information of either nominal or real claims with different maturities. In this paper, we study a novel term structure of assets that are direct claims to future dividends paid by firms to shareholders. Our data set is available at a daily frequency with maturities up to 10 years, with 1-year increments. Based on these dividend assets, we construct a term structure of equity yields that are analogous to real and nominal bond yields. The key difference between dividend assets and either nominal or real bonds is that the final payoff of dividend assets is variable whereas the payoff of nominal and real bonds is fixed in nominal and real terms, respectively. In this paper, we explore the information contained in equity yields across three major equity markets: the US, Europe, and Japan.

The equity yield at time t with maturity n can be written as the sum of three components. It consists of the nominal bond yield with maturity n, plus a maturity-specific risk premium that investors require for holding dividend risk, minus the expected dividend growth rate, which represents the average expected dividend growth over the next n periods. Higher discounting increases the yield, whereas higher expected dividend growth lowers the yield.[2]

Dividend assets, also called dividend strips, are generally traded in futures or swap markets, not in spot markets. Spot prices and futures prices are linked through bond prices. Assuming no-arbitrage, we can replace spot prices with futures prices in our computations to obtain forward equity yields, denoted by $e^f_{t,n}$, which do not depend on the n-year bond yield. The forward equity yield is simply equal to the difference between the maturity-specific dividend risk premium, which we denote by $\theta_{t,n}$, and the average n-year expected dividend growth rate $g_{t,n}$:

$$\underbrace{e^f_{t,n}}_{n\text{-year forward equity yield}} = \underbrace{\theta_{t,n}}_{\text{risk premium}} - \underbrace{g_{t,n}}_{\text{expected dividend growth}}. \tag{1}$$

This implies that, by definition, forward equity yields must either predict dividend growth rates or excess returns (in excess of bonds) on dividend assets, or both. A high (low) value of the forward equity yield implies that the risk premium is high (low) or that the expected

[1] See Singleton (1980), Singleton (1983), Fama and Bliss (1987), Piazzesi (2001), Ang and Piazzesi (2003), Ang and Monika Piazzesi (2006), Cochrane and Piazzesi (2005), Ludvigson and Ng (2009), Duffee (2011), among many others.

[2] There is a straightforward analogy with nominal and real bond yield. The difference between nominal and real bond yields is expected inflation and the inflation risk premium. Similarly, the difference between equity yields and nominal bond yields is expected dividend growth and the dividend risk premium.

dividend growth rate is low (high). This makes forward equity yields natural candidates to forecast dividend growth across various maturities. We find that forward equity yields fluctuate strongly over time, for all maturities, and for all geographic regions. These fluctuations are due to both expected dividend growth variation and risk premium variation. Particularly during the great recession, 1-year forward equity yields turn strongly positive with values above 30% for the US, and values above 50% for Europe and Japan. We find that for all regions, expected dividend growth rates were low (negative) and risk premia were high during this period.

This paper is the first to compute and analyze the behavior of the term structure of equity yields. Our new data set allows us to make two important additional contributions to the asset pricing literature. First, risk pricing across maturities has recently received a lot of attention. Important contributions in this literature are Lettau and Wachter (2007) and Hansen, Heaton, and Li (2008). In a recent paper, Binsbergen, Brandt, and Koijen (2011) show that, unconditionally, risk premia are high for short-maturity dividend strips, which seems puzzling for several leading asset pricing models. In this paper, we study the time variation in risk pricing (risk premia) across maturities. We find that the slope of the term structure of the dividend risk premium moves in a strongly pro-cyclical fashion. That is, long-maturity risk premia are higher than short-maturity risk premia during expansions and lower during recessions. The opposite holds for the slope of the term structure of expected dividend growth rates, which moves in a strongly counter-cyclical fashion. Further, the volatility of risk premia is decreasing with maturity. Hence, our paper contributes to a large literature documenting that the equity risk premium fluctuates over time.[3] We use equity yields to study whether the risk premium variation is largely driven by short- or long-maturity variation in risk premia, and conclude it is the former.

Second, we study the degree of comovement of dividend future returns across regions and compare it to the comovement in index returns across regions. On average, short-maturity dividend strip returns comove less compared to index returns, but the time variation in this comovement is much higher. The average correlation of the 2-year dividend future returns across regions is only 0.4, but increases to 0.8 in 2008. The correlation between the index returns across the three regions is on average higher than the dividend futures returns, but does not change as much over time. We also study the time variation in the CAPM betas of the 2-year and the 5-year dividend futures returns. We find that these betas are strongly time varying, and this time-variation is decreasing with maturity.

[3]See for instance Fama and French (1988), Cochrane (1991), Cochrane (2008), Lettau and Van Nieuwerburgh (2008), and Binsbergen and Koijen (2010).

The CAPM betas increase substantially during the great recession. In summary, dividend futures seem to have large time variation in their comovement with each other as well as with asset markets in general, providing an interesting avenue for future research as to why these assets have such high risk premia. In this way, we extend the literature on comovement across regions, see for instance Forbes and Rigobon (2002), by studying whether claims to short-maturity or long-maturity cash flows tend to comove more strongly.

To construct the prices of dividend assets and (forward) equity yields, we use a new data set on dividend futures prices with maturities up to 10 years. An index dividend future is a standardized contract where at a future time T, the owner pays the futures price, which is determined today, and receives the index dividends paid during calendar year T. Our daily data set covers the time period between October 2002 and April 2011 and comes from BNP Paribas and Goldman Sachs who are important players in the market for dividends. These banks have provided us with their proprietary dividend databases, which they use firm-wide both as a pricing source and to mark the internal trading books to the market. Before 2008, index dividend futures and swaps were traded in over-the-counter (OTC) markets. Since 2008, dividend futures are exchange-traded for several major indexes in an increasingly liquid market. Although the available sample is short, we do have information across three major economic regions which allows us to increase the power of our statistical tests.

1 Defining Equity Yields

An index dividend future is a standardized contract where, at maturity, the buyer pays the futures price, which is determined today, and the seller pays the dollar amount of dividends during a certain calendar year. Take for example the 2019 dividend futures contract on the DJ Eurostoxx 50 index, which on October 13th 2010 traded for 108.23 Euros. On the third Friday of December 2019, the buyer of the futures contract will pay 108.23 Euros, and the seller of the futures contract will pay the cash dividend amount on the Eurostoxx 50 index that has been paid out between the third Friday in December of 2018 and the third Friday in December of 2019. The contract is settled based on the sum of all dividends paid throughout the year, and there is no reinvestment of the dividends in the contract.

Let D_{t+n} denote the stochastic dividend paid out in n years from today's date t and let $g_{t,n}$ denote the average per-period expected growth rate of dividends over the next n

periods:

$$g_{t,n} = \frac{1}{n} E_t \left[\ln \left(\frac{D_{t+n}}{D_t} \right) \right]. \tag{2}$$

Then the present value $P_{t,n}$ of D_{t+n} is given by:

$$P_{t,n} = D_t \exp\left(n(g_{t,n} - \mu_{t,n}) \right), \tag{3}$$

which defines the (geometric) discount rate $\mu_{t,n}$. By splitting the discount rate into the nominal bond yield for period n, denoted by $y_{t,n}$, and a risk premium $\theta_{t,n}$ that compensates investors for dividend risk for maturity n, we can rewrite equation (3) as:

$$P_{t,n} = D_t \exp\left(n(g_{t,n} - y_{t,n} - \theta_{t,n}) \right). \tag{4}$$

The equity yield at time t with maturity n is then defined as:

$$e_{t,n} \equiv \frac{1}{n} \ln \left(\frac{D_t}{P_{t,n}} \right) = y_{t,n} + \theta_{t,n} - g_{t,n}.$$

The expression above shows that the equity yield consists of three components. It consists of the nominal bond yield $y_{t,n}$, a maturity-specific risk premium $\theta_{t,n}$ that investors require for holding dividend risk, and the expected dividend growth rate $g_{t,n}$, which represents the average expected dividend growth over the next n periods. Ceteris paribus, a higher expected dividend growth rate makes the price $P_{t,n}$ higher compared to the current level of dividends D_t. This results in a lower equity yield.[4]

In practice, the contracts we study are quoted not in terms of the "spot" price $P_{t,n}$, but in terms of the futures (or forward) price, which we will denote by $F_{t,n}$. Under no arbitrage, the spot price and the forward price are linked through the nominal bond yield:[5]

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

[4]In the rest of this paper we study log yields, log excess returns and log dividend growth rates. One may be worried that some of our predictability results are driven by time-varying volatility. Our conclusions remain unaltered if instead of geometric yields and growth rates we use arithmetic ones (no logs). The summary statistics and predictive regressions for arithmetic growth rates and yields are included in the appendix.

[5]This no-arbitrage relationship holds for non-dividend paying assets. At first sight this may be confusing, as the focus of the paper is on dividends. The index does indeed pay dividends, and therefore futures on the index are affected by these dividend payments. However, the futures contracts we study are not index futures, but dividend futures. These dividend futures have the dividend payments as their underlying, not the index value. As dividends themselves do not pay dividends, equation (5) is the appropriate formula.

We then define the forward equity yield $e^f_{t,n}$ as:

$$e^f_{t,n} \equiv \frac{1}{n}\ln\left(\frac{D_t}{F_{t,n}}\right) = \theta_{t,n} - g_{t,n}. \tag{6}$$

The forward equity yield is equal to the difference between the risk premium and the expected dividend growth rate. If the forward equity yield is high, this either implies that risk premia are high or that expected dividend growth rates are low.

Next, we derive the investment strategy that is required to earn the risk premium $\theta_{t,n}$. It can be earned by buying (going long in) the n-period forward contract at time t, holding it until maturity $t+n$ and collecting the dividends at period $t+n$. The n-period log return on this strategy is given by:

$$r^D_{t+n} = \ln\left(\frac{D_{t+n}}{F_{t,n}}\right) = \ln\left(\frac{D_{t+n}}{D_t}\right) + \ln\left(\frac{D_t}{F_{t,n}}\right). \tag{7}$$

Because the forward price is known at time t, but paid at time $t+n$, this is a zero-cost strategy, and no money is exchanged at time t. The expected return on this strategy is given by:

$$E_t\left[r^D_{t+n}\right] = E_t\left[\ln\left(\frac{D_{t+n}}{D_t}\right) + \ln\left(\frac{D_t}{F_{t,n}}\right)\right] = n\theta_{t,n}.$$

As with all forward and futures contracts, the replicating strategy of this derivative is to borrow in the n-year bond market, buy the asset (dividend strip) in the spot market, collect the payoff (dividend) at maturity and use the proceeds to pay off the bond. Because this replicating strategy involves shorting the n-year bond, investors forego the n-year bond risk premium. This will lead to a different risk premium $\theta_{t,n}$ compared to the risk premium that an investor would earn in the dividend strip spot market (see for example Binsbergen, Brandt, and Koijen (2011)).[6] Further, $\theta_{t,n}$ is the risk premium earned when the investment horizon is equal to the maturity of the futures contract n. So, for example, if n equals two years, then $\theta_{t,n}$ is the average annual risk premium earned when buying and holding the futures contract for 2 years and collecting the dividend at maturity.

[6] In addition, Binsbergen, Brandt, and Koijen (2011) report simple returns instead of log returns.

2 Data and Summary Statistics

2.1 Choice of Stock Indices

We focus our analysis on the dividends of three major stock indices representing three world regions: the US, Europe, and Japan. For Europe, we use the Eurostoxx 50 Index. This index is a leading blue-chip index for the Eurozone. The index covers 50 stocks from 12 Eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain traded on the Eurex. In February 2011, the index has a market capitalization of 2 Trillion Euros (2.8 Trillion dollars) and captures approximately 60% of the free float market capitalization of the Eurostoxx Total Market Index (TMI), which in turn covers approximately 95% of the free float market capitalization of the represented countries. As such, the index is fairly representative for the euro area despite the fact that it only includes 50 stocks. For Japan, we focus on the Nikkei 225 index, which is the major stock index for the Tokyo Stock Exchange in Japan. The Nikkei 225 has a market capitalization of over 2 Trillion dollars. It is comprised of 225 blue chip stocks on the Tokyo Stock Exchange. Finally, we use the S&P 500 index for the US. The S&P 500 is a capitalization-weighted index of the prices of 500 large-cap common stocks actively traded in the United States. The stocks included in the S&P 500 are those of large publicly-held companies that trade on one of the two largest American stock market exchanges; the NYSE and the NASDAQ. The market capitalization is just over 12 Trillion dollars. As a comparison, the S&P1500 index, which also includes mid-cap and small-cap companies, has a market capitalization of about 13 Trillion dollars, suggesting that the S&P 500 index is a representative index for the US economy.

2.2 Equity Yields

The market for dividend products is relatively young and started around the turn of the millennium. With increased trading activity in options, forwards, and structured products, dividend exposures increased on banks' balance sheets. This exposes banks to dividend risk, the risk between anticipated and actual dividends. Other than banks, hedge funds and pension funds are important participants in this market. Most of the trading in dividends occurs in the over-the-counter (OTC) market. Since mid 2008, however, exchange-traded dividend futures markets have started; first in Europe and later in

Japan.[7]

The current size of the exchange-traded dividend futures market is substantial, particularly in Europe, with a total open interest of $10 billion for the Eurostoxx 50 index. This is in addition to a large OTC market. For example, by mid October 2010, the open interest in the exchange-traded Dec 2010 dividend futures contract on the Eurostoxx 50 was $1.7 billion. The open interest in the Dec 2011 contract was $2.5 billion. The open interest decreases for longer maturity contracts, but even the Dec 2019 contract has a 200 million dollar open interest.

The pay-off of a contract is the sum of the declared ordinary gross dividends on index constituents that go ex-dividend during a given year. Special or extraordinary dividends are excluded.[8] Contracts are cash-settled at the expiration date and there are no interim cash flows. So, for example, the payoff of the 2019 dividend futures contract on the Eurostoxx 50 index is the declared ordinary gross dividends on index constituents that go ex-dividend between the third Friday of December of 2018 and the third Friday of December in 2019.

To compute daily dividends, we obtain daily return data with and without distributions (dividends) from S&P index services for the S&P 500 index. We use Global Financial Data and Bloomberg to obtain the same objects for the Eurostoxx 50 index and the Nikkei 225 index. Cash dividends are then computed as the difference between the return with distributions and the return without, multiplied by the lagged value of the index. As the dividend futures prices are based on a full calendar year of dividends, we use the past year of dividends as the numerator in equation (6). For example, if we want to compute the equity yields on October 15th 2010, we use as the numerator the sum of the dividends paid out between October 16th 2009 and October 15th 2010. This also reduces concerns related to seasonal effects, as both the dividend futures price and the current dividend level refer to a whole year of dividends.

2.2.1 Equity yields of the S&P 500

The forward equity yields for the S&P 500 index between October 2002 and April 2011 are plotted in Figure 1. The four lines in each graph represent the yields for four different

[7]Exchange-traded dividend futures are also available for the FTSE 100 index in the United Kingdom, the HSI and HSCEI indices in Hong Kong, for the AEX index in the Netherlands, and for Russian energy companies. Finally, individual stock dividend futures are also available for all constituents of the Eurostoxx 50 index and 13 UK underlyings.

[8]Over time, the share of special dividends as a fraction of total dividends, has decreased and is negligible for the sample period that we consider, see DeAngelo, DeAngelo, and Skinner (2000).

horizons: 1, 2, 5, and 7 years. The graph shows that between 2003 and 2007, short-maturity yields were lower than long-maturity yields. During the financial crisis this pattern reversed and short-maturity yields sharply increased compared to long-maturity yields. However, long-maturity yields also increased substantially during this period. This implies that expected growth rates went down and/or risk premia went up, both for the short run and the long run.

The 1-year forward equity yield for the S&P 500 index displays a double peak, the first occurring on December 15th 2008 and the second occurring on March 4th of 2009, with values of 29.3% and 35.5%, respectively. During this sample period, the S&P 500 index level exhibits a double dip, but the troughs occurred on November 20th 2008, with a level of 752.44 and March 5th with an index level of 682.55. On March 4th, the 2-, 5-, and 7-year yields have values of 29.6%, 10.6% and 6.9% respectively. Finally, a very steep increase in the 1-year rate occurred in October 2008 when the rate increased from 6.6% on October 1st to 28.0% on October 30th. Interestingly, the S&P 500 index level during this period only dropped from 1161.1 on October 1st to 954.1 on October 30th, which is substantially higher than its two troughs of 752.44 and 682.55. Long-maturity yields increase further between October 30th 2008 and November 20th 2008 when the index dropped another 22% from 968.8 to 752.44, but short-maturity yields, stay roughly constant. This suggests that during the month of October 2008 predominantly short-term expectations were adjusted downwards, whereas in November, financial market participants realized that the financial crisis was going to last a long time.

2.2.2 Equity yields of the Eurostoxx 50 Index

In Figure 2, we plot the forward equity yields for the Eurostoxx 50 index. As before, the four lines in each graph represent four horizons: 1, 2, 5, and 7 years. The peak of the 1-year yield occurs on March 30th 2009 with a yield of 53.4%. Similar to the S&P 500 index, the peak of the 1-year yield occurred after the trough of the index level, with the latter occurring on March 9th 2009, when the index value hit 1810 Euros. Compared to the troughs of the S&P 500 index, the troughs of the Eurostoxx 50 index occurred later, both for the index and for the 1-year yield. As with the S&P 500 index, there is one particular period of a very steep increase for the 1-year yield. Between October 1st and October 24th 2008 this yield increased from 8.8% to 50.5%.

2.2.3 Equity yields of the Nikkei 225

In Figure 3, we plot the forward equity yields for the Nikkei 225 index. The peak of the 1-year yield occurs on March 25th 2009 with a value of 58.5%. The index reached its trough on March 10th 2009 with an index level of 7055.0, which (like the other two indices) is before the 1-year yield reached its peak.

Between October 1st and October 30th 2008, the 1-year equity yield increased from 5.6% to 29.6%. Apart from this steep increase, there is no particular period over which the yield increased abruptly and the yield drifts upward gradually to its peak of 58.5%. There is also a marked increase by the end of the sample as a consequence of the earthquake and tsunami in March 2011 as further discussed in Section 7.3.

2.2.4 Summary statistics of the forward equity yields for all three markets

We report in Table 1 the summary statistics of the forward equity yields for all three indices and for 7 maturities. The average 1-year yield is highest for Europe (2.4%) and lowest for Japan (-3.6%). The average 1-year yield for the US is -2.8%. The average 7-year yield is -2.5% for the US, -2.4% for Japan and 0.7% for Europe.

The volatilities of the yields decline monotonically with maturity for all three indices, similar to bond yields (see for instance Dai and Singleton (2003)). The volatility of yields is highest for Japan and lowest for the US at all maturities. Further, over this sample period the yields are positively skewed, which is largely driven by the large positive numbers during the financial crisis.

2.3 Bond Yields

We use monthly Fama-Bliss bond yields with maturities of 1,. . . , 5 years from the Center for Research in Security Prices (CRSP). For real yields and credit spreads, we use data from the Board of Governors of the Federal Reserve System.[9]

3 Comovement

First, we study the comovement between the dividend futures returns across regions and compare this with the comovement in index returns across regions. Let $R^i_{t,n}$ denote the (excess) return at time t on the dividend futures with maturity n in region i. We start by computing rolling 24-month correlations between each of the regions. Let $\rho^{ij}_{n,t}$ denote the

[9]See http://www.federalreserve.gov/econresdata/researchdata.htm.

rolling correlation between region i and region j, using monthly data between time $t-23$ and t, for dividend futures returns with maturity n.[10] Because we have three regions, we have three correlation measures: (1) the correlation between the US and Europe, (2) the correlation between the US and Japan, and (3) the correlation between Japan and Europe. At each time t, we take the simple average of these three correlations as an aggregate measure of comovement.

$$\bar{\rho}_{n,t} = \frac{\rho_{n,t}^{us,eur} + \rho_{n,t}^{us,jap} + \rho_{n,t}^{eur,jap}}{3}. \tag{8}$$

Figure 4 plots $\bar{\rho}_{n,t}$ for $n = 2$ and 5 years as well as for the index returns. The figure shows that on average the comovement in 2-year dividend futures returns across regions is lower than that of the 5-year dividend futures returns, which in turn is lower than the comovement of the indices. However, during the great recession, the comovement in 2-year dividend futures increases the most, and reaches the same level as the comovement in index returns. This suggests that, during bad aggregate economic states, short-maturity claims strongly comove across markets. Long-maturity claims, such as the aggregate stock market, are highly correlated during recessions as well as expansions.

Second, we study the comovement between dividend futures returns and their corresponding index returns. We compute CAPM betas for the 2-year and 5-year dividend futures returns for each region by regressing dividend futures returns (which are excess returns) onto the excess returns of the corresponding index. Binsbergen, Brandt, and Koijen (2011) show for the US that 2-year dividend strip returns have an unconditional beta well below one on average, despite the fact that the average returns on these short-maturity claims are higher than the average returns on the aggregate stock market. This implies that the alphas on short-maturity dividends strips are economically large.

We then study how the betas move over time, using data across multiple maturities and all three regions. At each point in time, we compute 24-month rolling CAPM betas. We average the betas across the three regions and plot this aggregated measure in Figure 5. The graph shows that there is substantial variation in the CAPM betas. The average beta is well below one, but the conditional beta varies substantially over time and increases substantially as a consequence of the events related to the financial crisis.

To formally test for the time variation in CAPM betas, we model the beta as a function

[10]Using weekly or daily data leads to similar results.

of the lagged 2-year equity yield. That is, we run the following regressions:

$$R^i_{t,n} = \alpha_{i,n} + \left(\beta^0_{i,n} + \beta^1_{i,n} e^{i,f}_{t-1,2}\right)\left(R^i_{t,I} - R_{f,t}\right) + \varepsilon_t \tag{9}$$

where $R^i_{t,I}$ is the monthly return on the stock index at time t in region i, $e^{i,f}_{t,2}$ is the 2-year forward equity yield at time t in region i, $R_{f,t}$ is the risk free rate at time t, and n indicates the maturity of the contract in years. The results are summarized in Table 2. The results show that for 2-year dividend future returns, the coefficient $\beta^1_{i,2}$ is large with values of around 1.1. The statistical significance varies across regions: the coefficient is significant at the 1% level for Japan and significant at the 10% level for Europe (p-value of 6%). The coefficient is insignificant for the US, but the magnitude of the coefficient is similar to that of Europe and Japan. For the 5-year dividend futures returns, the estimated coefficients $\beta^1_{i,5}$ are on average smaller than for the 2-year dividend returns, and only significant for Japan. If we look at all regions together, the evidence suggests that the average beta is low, and is positively related to equity yields. During economic downturns, when equity yields increase because risk premia increase and expected growth rates decline, dividend strips comove more strongly with the aggregate stock market. The variation in betas is economically large. The standard deviation of the 2-year equity yield ranges from 0.08 in the US to 0.15 in Japan. This implies that if equity yields increase from minus one to plus one standard deviation from their mean, the beta of short-maturity dividend strips increases by 0.2-0.3.

Overall, our evidence suggests that dividend futures returns on average have low comovement across regions as well as with the index. However, during bad times, this comovement can increase substantially, and short-maturity claims become highly correlated, both with each other as well as with the index. This uncertainty about comovement and betas provides additional guidance as to why the average risk premium on these claims is so high.

4 Dividend Growth Predictability and Risk Premia

Forward equity yields depend on n-year growth expectations and a maturity-specific risk premium. In this section, we decompose equity yields into these two components. First, we use equity yields to forecast future dividend growth. This approach follows a long tradition in macro-finance using yield-based variables to forecast either returns or cash flows. Examples include Campbell and Shiller (1988), Cochrane (1991), and Binsbergen and Koijen (2010) for the aggregate stock market, Fama (1984) for currency markets, and Fama and Bliss (1987), and Campbell and Shiller (1991), and Cochrane and Piazzesi (2005) for bond markets. Once we have taken a stance on a forecasting model for dividend growth, we can take the sum of this forecast and the equity yield to obtain an estimate for the risk premium, see equation (6).

One important question is which forecasting model we should use for dividend growth. In the appendix, we present a Bayesian Model Averaging (BMA) approach to compare the forecasting performance of forward equity yields to a set of linear prediction models that are commonly used in the empirical literature to predict economic growth. We conclude that using two equity yields as the predictors appears to outperform all the other specifications we consider. Because equity yields move due to expected dividend growth variation as well as risk premium variation, we use two equity yields on the right-hand side of the regression, not one. This mitigates the influence of the risk premium. If both expected dividend growth and risk premia follow a one factor specification, using two equity yields in the regression fully mitigates the influence of the risk premium variation, thereby uncovering the expected dividend growth component.[11] If either risk premia or expected dividend growth follow a higher order factor model, more yields can be included as explanatory variables in the regression.

4.1 Dividend Growth Predictability in the US

We first run a set of univariate regressions to explore the predictability of dividend growth by forward equity yields in the US. We focus on annual dividend growth to avoid the impact of seasonal patterns in corporate payout policies, but we use overlapping monthly observations to improve the power of our tests. We run the following regressions for $n = 1, .., 5$ years and t is measured in months:

$$\Delta d_{t+12} = \alpha_n - \beta_n e^f_{t,n} + \varepsilon_{d,t+12}, \tag{10}$$

where:

$$\Delta d_{t+12} \equiv \ln\left(\frac{\sum_{i=1}^{12} D_{t+i}}{\sum_{i=1}^{12} D_{t-12+i}}\right). \tag{11}$$

The realized growth rate Δd_{t+12} is based on the summed dividends within the year, which is also the measure of aggregate annual dividends the futures contract is based upon.[12]

[11] Such a factor specification is suggested by the models of Bansal and Yaron (2004), Lettau and Wachter (2007), Lettau and Wachter (2010), Menzly, Santos, and Veronesi (2004), Croce, Lettau, and Ludvigson (2009) and Bekaert, Engstrom, and Xing (2009).

[12] Summing the dividend within the year is also done by Fama and French (1988). Alternatively, one could reinvest dividends at the 1-month T-bill. Binsbergen and Koijen (2010) show that the resulting

We regress the growth rates on $-e^f_{t,n}$ so that if the risk premium on the 1-year equity yield is constant, the regression slope $\beta_1 = 1$. Put differently, a deviation of β_1 from 1 implies that the risk premium embedded in the 1-year forward equity yield is time-varying.[13]

The results are presented in the second through fourth column of Table 3. The second column reports the point estimate. The third column reports the t-statistic using Hansen and Hodrick (1980) standard errors. The fourth column reports the R-squared value. We find that all forward equity yields have strong predictive power for future dividend growth. The R-squared values are high and vary between 48% for the 5-year yield and 76% for the 1-year yield. This suggests that dividend growth rates are strongly predictable, at least during this sample period. The R-squared value of the regression monotonically decreases with the maturity of the yields.

Second, we find that the absolute size of the predictive coefficients is decreasing in maturity. As a point of reference, it may be useful to derive what these coefficients look like under two, admittedly strong, assumptions. Namely, if we assume that the risk premium on short-dividend strips is zero and one-period expected dividend growth is an AR(1) process with autoregressive coefficient ρ, then it is straightforward to show that:

$$\beta_n \simeq \frac{n(1-\rho)}{1-\rho^n}. \tag{12}$$

This expression directly implies $\beta_1 = 1$, as discussed before. We can also solve for ρ for $n = 5$ given $\beta_5 = 1.9$. This corresponds to an annual autoregressive coefficient of $\rho = 0.67$. This illustrates how the cross-section of predictive coefficients can be informative about the persistence of $g_{t,n}$.

Because we use log dividend growth rates and log yields, one may be worried that some of our predictability results are driven by time-varying volatility. Our conclusions remain unaltered if instead of geometric yields and growth rates we use arithmetic ones (no logs). The summary statistics and predictive regressions for arithmetic growth rates and yields are included in the appendix.

4.2 Risk Premia

In the appendix we explore a set of prediction models to forecast dividend growth and use techniques from Bayesian Modeling Averaging to compute posterior probabilities for each

aggregate dividend growth series is very similar for both reinvestment policies.

[13] The opposite implication does not hold. Even if $\beta_1 = 1$, the risk premium can move over time, as expected dividend growth and risk premia can be highly correlated.

forecasting model. As we stated above, we find that using two equity yields as the predictor variables for dividend growth outperforms all other specifications we explore. If both expected dividend growth and risk premia follow a one-factor specification, then indeed, two equity yields should suffice to back out the expected dividend growth component.[14]

Let x denote the vector of the 2-year and 5-year equity yields:

$$x_t = \left[e^f_{t,2} \;\; e^f_{t,5} \right]'. \tag{13}$$

Our model for expected dividend growth is then given by:

$$g_{t,n} = E_t \left(\Delta d_{t+12} \right) = \psi_0 + \psi_1' x_t, \tag{14}$$

where we estimate the coefficients ψ_0 and ψ_1 by ordinary least squares (OLS) using overlapping monthly observations of annual dividend growth. Recall that forward equity yields relate to expected growth rates and the risk premium component as follows:

$$e^f_{t,n} \equiv \theta_{t,n} - g_{t,n}. \tag{15}$$

Rewriting this equation we find:

$$\theta_{t,n} = e^f_{t,n} + g_{t,n}. \tag{16}$$

To compute n-year risk premia (where $n > 1$), we need n-year growth expectations $g_{t,n}$. To compute these expectations, we model the time-series dynamics of forward equity yields as a first-order vector autoregressive (VAR) model:

$$x_{t+1} = \mu + \Gamma x_t + \varepsilon_{t+1}. \tag{17}$$

The monthly VAR model implies an annual VAR model:

$$x_{t+12} = \mu_A + \Gamma_A x_t + \varepsilon_{A,t+12},$$

[14]If one has a strong prior that other predictors should be added to the predictive relationship, then these predictors can easily be included. As argued before, given the definition of forward equity yields, any estimate of expected dividend growth can be combined with the yields to arrive at an estimate of the risk premium.

where:

$$\mu_A \equiv \left(\sum_{i=0}^{11} \Gamma^i\right) \mu,\ \Gamma_A \equiv \Gamma^{12},\ \varepsilon_{A,t+12} \equiv \sum_{i=1}^{12} \Gamma^{12-i} \varepsilon_{t+i}.$$

As before, we estimate the parameters using OLS.

Using the joint dynamics for dividend growth from (14) and the forward equity yields (17), we can compute the conditional expectation of 1-year dividend growth as:

$$\begin{aligned} E_t\left(\Delta d_{t+12}\right) &= \psi_0 + \psi_1' x_t \\ &\equiv \gamma_{0(1)} + \gamma_{1(1)}' x_t. \end{aligned}$$

and the expectation of annual dividend growth n years ahead ($n > 1$) as:

$$\begin{aligned} E_t\left(\Delta d_{t+12n}\right) &= E_t\left(\psi_0 + \psi_1' x_{t+12(n-1)}\right) \\ &= \psi_0 + \psi_1' \left(\left[\sum_{i=0}^{n-2} \Gamma_A^i\right] \mu_A + \Gamma_A^{(n-1)} x_t \right) \equiv \gamma_{0(n)} + \gamma_{1(n)}' x_t. \end{aligned}$$

The forward equity yield can now be written as:

$$\begin{aligned} e_{t,n}^f &= \theta_{t,n} - g_{t,n} \\ &= \theta_{t,n} - \frac{1}{n} \sum_{i=1}^{n} \left(\gamma_{0(n)} + \gamma_{1(n)}' x_t\right). \end{aligned}$$

We observe the left-hand side, $e_{t,n}^f$, and we estimate the second term on the right-hand side using the VAR. This results in an estimate for the risk premium, $\theta_{t,n}$ for all maturities n.

The results are presented in the top panel of Figure 6, where the solid line plots the 2-year risk premium and the dotted line plots the 5-year risk premium. The graph shows that the risk premium varies over time, and increases during the recent financial crisis. The average risk premium for the 2-year and 5-year yield are about same and equal to 2.8% per year for the 2-year yield and 3.1% per year for the 5-year yield.[15]

[15] The number for the 2-year (annualized) risk premium is lower than the annualized average simple monthly returns on 1.5 year dividend strips reported in Binsbergen, Brandt and Koijen (2011). This difference can be explained as follows. First, because $\theta_{t,n}$ is a geometric risk premia (logs), there is a Jensen term that makes the average simple return higher. Secondly, the risk premium $\theta_{t,n}$ does not include the bond risk premium. The average simple excess return on two-year bonds equals 9bp per month over this sample period, which in annualized terms adds up to more than a percent. To further explore the difference, we compute the simple monthly return on a return strategy where we go long in

We find that the risk premium estimates fluctuate substantially over time. In fact, the estimates imply that the short-maturity risk premium component fluctuates more than the longer-maturity component.[16] Perhaps most interestingly, we find that the term structure of risk premia is more inverted during the recession. The results in Binsbergen, Brandt, and Koijen (2011) already suggest that the risk premium component on the short-maturity dividend claims is on average higher than on the long-maturity dividend claims.[17] We extend this evidence by showing that the slope of the term structure of risk premia is pro-cyclical.

In the top panel of Figure 7, we decompose the 2-year forward equity yield of the S&P 500 into expected growth rates and risk premia. The plot shows that both risk premia and expected growth rates vary substantially over time. Furthermore, during the financial crisis, expected growth rates went down, whereas risk premia sharply increased.

Finally, we do a variance decomposition of the equity yields into expected dividend growth rates and the risk premium:

$$\operatorname{var}\left(e^f_{t,n}\right) = \operatorname{cov}\left(e^f_{t,n}, \theta_{t,n}\right) - \operatorname{cov}\left(e^f_{t,n}, g_{t,n}\right). \tag{18}$$

Dividing both sides of the equation by the variance of the equity yields gives a variance decomposition of equity yields into the contribution of expected growth rates and risk premia. The results are summarized in Table 4. The second and third column of the table show that during our sample period, the majority of the variance of equity yields is driven by expected dividend growth rates. For the 2-year yield, about 80% of the total variation is driven by expected dividend growth. The risk premium variation explains the remaining 20%. For the 5-year yield, these numbers are 72% and 28% respectively.

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the 2-year dividend futures contract, hold this contract for a year (when the maturity of the futures has decreased from 2 years to 1 year) and then go long in the new 2-year dividend futures contract until we reach the end of our sample. As argued before, because we are investing in futures contracts, this return is already an excess return in excess of bonds. We find that the average excess return on this strategy over this sample period is 71 basis points per month, consistent with the results in Binsbergen, Brandt and Koijen (2011).

[16] The 2-year risk premium turns somewhat negative during the period 2006-2007. As an extension, one can consider to estimate the model under the condition that the risk premium component needs to be positive, see also Campbell and Thompson (2007).

[17] This is consistent with the models developed in Lettau and Wachter (2007), Lettau and Wachter (2010), Croce, Lettau, and Ludvigson (2009), Barro, Nakamura, Steinsson, and Ursua (2011), Lynch and Randall (2011), and Buraschi, Porchia, and Trojani (2010).

4.3 Predictability and Risk Premia in Europe and Japan

We repeat the same analysis for Europe (the Eurostoxx 50) and Japan (the Nikkei 225). Our findings for these two indices are consistent with the results we find for the S&P 500 index. The univariate predictability results are presented in columns 5 through 10 of Table 3. As is the case for the S&P 500 index, dividend growth seems strongly predictable, with R-squared values above 60%. The risk premia, shown in the second and third panel of Figure 6, vary strongly over time and are always positive. The average value of the risk premia is high and higher than for the US. For Europe the average risk premium is 9.1% for the 2-year contract and 8.5% for the 5-year contract. For Japan, the average risk premium is 6.1% for the 2-year contract and 5.6% for the 5-year yield. We do stress again that the sample period is rather short, which makes the estimation of these unconditional means imprecise.

The decomposition of the yields into expected growth rates and risk premia is presented in the middle and bottom panels of Figure 7. As for the S&P 500 index, forward equity yields seem to vary both due to risk premium fluctuations as well as due to variation in expected dividend growth. The variance decomposition in Table 4 shows that for Japan and Europe, the majority of the variance of equity yields is due to variation in expected dividend growth. In this case, the 2-year yield is driven less by expected dividend growth and more by the risk premium variation compared to the 5-year yield.

4.4 The World Risk Premium and Expected Dividend Growth

We now combine the estimates across the three regions to compute a world risk premium and a world expected dividend growth rate. We compute the world risk premium and the world expected dividend growth rate by GDP-weighting the individual risk premium and expected dividend growth estimates. The results are plotted in Figure 9. The graph illustrates that the slope of the term structure of the world risk premium is pro-cyclical. That is, the difference between the 5-year and the 2-year risk premium is positive in expansions, and negative in recessions. The slope of the term structure of expected dividend growth is counter-cyclical. That is, the 5-year expected dividend growth rate is higher than the 2-year expected growth rate during the great recession, and lower during expansions.

5 Do Equity Yields Contain Other Information Than Bond Yields?

To assess whether forward equity yields contain information beyond and above the information contained in bond yields, we compute the principal components of equity yields, nominal bond yields and real bond yields. In all cases, the first principal component of each category of yields explains more than 95% of the variation of that category. We then regress each of the forward equity yields on the principal components of nominal and real bond yields.[18] Table 6 reports the R-squared values of these regressions. We only report results for the first two principal components for nominal and real bonds, because adding the third component leads to almost identical results as using two principal components. Furthermore, nearly all variation in nominal and real bond yields is captured by their first two principal components.

The table shows that the first two principal components of nominal yields explain between 30-37% of forward equity yield movements. The R-squared values are increasing in the maturity. When using the principal components of real yields, we find very low R-squared values, never exceeding 6%. When we include the first two principal components of real yields and the first two principal components of nominal yields in one regression (four regressors), the R-squared values increase to 75% for the 1-year forward equity yield, and 60% for the 5-year forward equity yield. This still leaves a substantial fraction of the variation in forward equity yields that is unexplained by the term structure of interest rates.

To further assess the relationship between bond yields and forward equity yields, Table 7 describes the correlations between the first two principal components of forward equity yields, the first two principal components of nominal bond yields and the first two principal components of real bond yields. We find that the first principal component of forward equity yields is generally negatively correlated with nominal bond yields, but positively correlated with real yields. This holds regardless of whether we compute the correlation between the levels of the yields or between the innovations in the yields computed from a VAR(1) model.

[18] An advantage of using principal components is that they are less sensitive to measurement error than individual yields.

6 Consumption Growth

6.1 Dividends, Consumption and GNP

Dividend markets provide us with a term structure of expected dividend growth. One may wonder to what extent dividends (and nominal dividend growth) are related to more common measures of economic activity such as real consumption and GNP. If they are strongly related, then forward equity yields may be good predictors of those measures of economic activity as well, which is what we explore in this section. To explore this relationship, we plot in Figure 8 the cyclical component of the Hodrick-Prescott filtered series for annual real consumption (levels), annual real GNP, and annual (nominal) dividends, at a quarterly frequency. As inflation was low and not particularly variable during our sample period, the results look very similar when using nominal consumption and nominal GNP numbers. We set the smoothing parameter to the standard value of $\lambda = 1,600$.

The graph shows that for many periods of expansions and recessions, the cyclical components of dividends, GNP, and consumption align. However, they are not perfectly aligned. Sometimes dividends lead consumption and GNP, and sometimes consumption and GNP lead dividends. However, the series align for the recent financial crisis as well as the recession in the early 2000s.

To illustrate the correlation between the cyclical components of consumption, GNP, and dividends, we compute the 10-year rolling time-series correlation between the series. The results are reported in Figure 10. First, the figure indicates that the correlation between the cyclical components of consumption and dividends or GNP and dividends are very similar. The time series of the rolling correlations strongly co-move. Second, apart from the early sixties and the nineties, the time-series correlation appears well above 0.5 and peaks in periods with deep recessions. This suggests that dividends and other measures of economic activity are strongly related. The last data point in the figure shows that the correlation between consumption and dividends over the past ten years, which roughly corresponds to our sample period, is around 0.8.

6.2 Univariate Regressions

The previous results show that our newly-constructed data set of forward equity yields is useful in forecasting future dividend growth. We now extend these results for the US and show that S&P 500 forward equity yields also predict future annual consumption growth. We study the same type of forecasting regressions as before, but now predict annual real growth rates using overlapping *quarterly* data:

$$\Delta c_{t+4} = \ln \left(\frac{\sum_{i=1}^{4} C_{t+i}}{\sum_{i=1}^{4} C_{t-4+i}} \right), \tag{19}$$

where C_t is real quarterly consumption of nondurables and services.[19] We run the regressions:

$$\Delta c_{t+4} = \alpha_n - \beta_n e^f_{t,n} + \varepsilon_{c,t+4}. \tag{20}$$

We present the results in Panel A of Table 5. Consistent with our results for dividend growth predictability, we also find predictability of 1-year consumption growth. The coefficients are much smaller in this case, which follows from the fact that dividend growth is more volatile than consumption growth during our sample period. As expected, the coefficients are increasing with maturity as long-maturity yields are less exposed to fluctuations in short-maturity expected growth rates.

As a point of reference, we use in Panel B of Table 5 nominal bond yields to forecast annual consumption growth. We use either the 1-year or the 5-year bond yield, or the yield spread between the 5-year and 1-year bond yields. Even though the 5-year bond yield is a fairly strong predictor of consumption growth, it is not nearly as powerful as the forward equity yields as reported in Panel A. In Panel C, we show that even using real bond yields, we do not uncover strong predictability. Even though the yield spread is statistically significant, the R-squared values are low.[20]

There is a long literature studying the predictability of consumption growth using bond yields, see for instance Harvey (1988) and Kandel and Stambaugh (1991). The reason why our equity yields may be superior predictors of growth may be due to the fact that the link between short-maturity interest rates and expected inflation has been unstable, see for instance Clarida, Gali, and Gertler (2000), Cogley and Sargent (2005), and Ang, Boivin, Dong, and Loo-Kung (2010). In addition, the sample period that we are studying may be special as the nominal short rate is close to zero for some part of the sample. The zero lower bound on interest rates may introduce non-linear relations between growth and both nominal and real bond yields, see for instance Christiano, Eichenbaum, and Rebelo (2011). Equity yields (and forward equity yields) are not subject do these concerns. Equity yields rise during recessions and are unrestricted in their sign.

[19]As in common in the forecasting literature for consumption growth, we use real consumption growth. Using nominal consumption growth leads to highly similar results.

[20]For real bonds, we use the spread between 5-year and 2-year yields due to data availability.

7 Applications

7.1 Economic Outlook Around the World

We now use the framework we develop in Section 4.2 to compute longer-term growth expectations. As before, instead of using a single equity yield, we use two forward equity yields with maturities equal to 2 and 5 years, respectively. As argued before, we use multiple equity yields as there may be separate factors driving expected growth rates and the risk premium component.

In Figure 11, we plot the 2-year and 5-year expected growth rates across regions. First, the troughs of the financial crisis for the 2-year expected growth rate were more severe for Japan and Europe than for the US. Second, 2-year expected growth rates decline substantially to -30% in Europe in the bottom of the crisis. Even for the 5-year horizon there is a double digit decline in expected growth. The figures also show a marked decline in both 2-year and 5-year growth expectations in Japan following the earthquake.

In Figures 12 and 13 we plot the term structures of forward equity yields and expected dividend growth rates on March 31st 2011 for all three regions. The term structure of equity yields for the US and Europe are upward sloping, whereas the term structure of expected dividend growth is downward sloping, suggesting that dividends are expected to grow faster in the short run than the long run, signaling the recovery from the steep decline in dividends in 2008 and 2009. Due to the earthquake in Japan, the term structure of expected growth in Japan is upward sloping, implying that dividends are expected to grow slower in the short run than in the long run. Just before the earthquake this term structure was downward sloping, as in Europe and in the US.

7.2 Growth Expectations and the Financial Crisis

In this section we study the term structure of forward equity yields during the financial crisis. We focus on particular months in which there was a large increase in either the short-maturity or the long-maturity yields (or both). Our main focus is on the S&P 500 index.

7.2.1 November 2007

Between October 31st and November 30th 2007, the 1-year forward equity yield for the S&P 500 index increased from -9.0% to -2.6%. The 5-year yield increased from -5.4% to -3.6%, the 10-year equity yield increased from -4.1% to -3.2% and the index value changed from 1549.4 to 1469.7, a drop of 5%. During this period the following important economic events occurred. First, on October 31st, Meredith Withney, an analyst at Oppenheimer and Co. predicted that Citigroup had so mismanaged its affairs that it would have to cut its dividends or go bankrupt.[21] By the end of that day, Citigroup shares had dropped 8%, and four days later, Citigroup CEO Chuck Prince resigned. Second, on October 31st, the FOMC lowered the target rate by 25bp to 4.5%. Third, on November 2nd the Fed approved the Basel II accord. Fourth, on November 27th, Citigroup raised $7.5 billion from the Abu Dhabi investment authority. Finally, the St. Louis Fed crisis time line notes for November 1st 2007: "Financial market pressures intensify, reflected in diminished liquidity in interbank funding markets."

7.2.2 September 2008

The month of September 2008 was a very turbulent month for financial markets. For example, on September 7th, the Federal Housing Finance Agency (FHFA) placed Fannie Mae and Freddie Mac in government conservatorship, and on September 15th, Lehman Brothers Holdings Incorporated files for Chapter 11 bankruptcy protection. Perhaps surprisingly, forward equity yields for the US did not change all that much in September for all maturities. As an illustration, the 1-year yield was 6.4% on September 1st and 6.3% on September 30th, and the volatility of the 1-year equity yield was low. For the US, most of the drop in short- and long-term expectations occurred in October. Growth expectations in Japan and Europe on the other hand, did substantially drop in September as well as in October. For Europe, between September 1st and September 30th, the 1-year yield increased from 4.0% to 8.2%, and the 10-year yield increased from 0.8% to 1.8%. For Japan, the 1-year yield increased from -5.4% to 4.7% and the 10-year yield increased from -2.0% to -0.1%.

7.2.3 October 2008

During the month of October 2008, the 1-year yield in the US increased from 6.6% on October 1st to 26.0% on October 31st. Over the same period, the 2-year yield increased from 3.5% to 16.2%, the 5-year yield increased from 0.5% to 4.8%, and the 10-year yield increased from 0.1% to 1.4%. Several major events happen during this time period. Interestingly, we find that one of the largest increases in the 1-year forward equity yield occurred shortly after former Federal Reserve chairman Alan Greenspan testified before the House Committee of Government Oversight and Reform.

[21] See "The Big Short" (Lewis (2010)).

7.3 Growth Expectations and the Earthquake in Japan

The earthquake and subsequent tsunami in Japan in mid March of 2011 had a significant impact on implied growth in Japan for all maturities. Equity yields for all maturities increased each day from Monday the 14th to Thursday the 17th of March, to recover slightly on the joint G-7 intervention on Friday the 18th. The 1-year equity yield increased from -3.3% to 6.9% in the first four days, to rebound to 5.2% on Friday March 18th (the G-7 intervention). Similarly, the 2-year equity yield increased from -1.4% to 4.8% to settle at 4.3%. Even the 7-year equity yield changed from -0.1% to 2.3% and eventually settled at 1.9% on the 18th. This indicates that financial markets expected a long-lasting influence on the Japanese economy. The US and Europe were much less affected by the Japanese situation, which illustrates that financial markets view these events as largely Japan-specific, rather than having an impact on global growth.

The equity yields for Europe seem largely unaltered by the events. During this period, the short-maturity yields of the US slightly lowered, but the long-maturity yields are unaffected. It is unclear whether this can be attributed to the crisis in Japan.

8 Conclusion and Future Work

We study a new data set of dividend derivatives with maturities up to 10 years across three world regions: the US, Europe, and Japan. We use these asset prices to construct equity yields, analogous to bond yields. We decompose these yields to obtain a term structure of expected dividend growth rates and a term structure of risk premia, which decomposes the equity risk premium by maturity. We find that the slope of the term structure of risk premia is pro-cyclical, whereas the slope of the term structure of expected dividend growth rates is counter-cyclical. The comovement of yields across regions is on average higher for long-maturity yields than for short-maturity yields, whereas the variation in this comovement is much higher for short-maturity yields.

Given the voluminous literature on the term structure of nominal and real bond yields, there are obviously many other interesting research questions worth exploring now that we have constructed a term structure of equity yields. First, a central question in asset pricing is how information about the macro economy gets incorporated into asset prices. This question spurred a large literature on the impact of macro-economic announcement for equity and fixed income markets. However, different macro-economic announcements may have different effects for short- and long-maturity claims. Equity yields can be used to understand which shocks have a short-term impact and which ones have a long-term impact on expected growth and risk premia.

Second, starting with Fama and Schwert (1977), the link between inflation and asset prices, such as equities, has attracted a lot of attention. However, one may argue that stocks are a real asset in the long-run, yet inflation may impact stock prices in the short run. One can use equity yields to trace out how news about inflation affects equity yields at various maturities. Given that we have data on the US, Europe, and Japan, whose inflationary environments are markedly different, we may be able to learn about the interaction between the price level, monetary policy, and the stock market.

Third, it would be interesting to understand how exchange rates and equity yields are related. Following the international finance literature initiated by Fama (1984) that studies the link between short-maturity interest rates and future exchange rate changes, we can use short-maturity equity yields in for instance Japan and the US to forecast changes in the US Dollar-Yen exchange rate. Our preliminary exploration of this question suggests that equity yields alone, or combined with short rates, can forecast exchange rate changes.

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Maturity in years	1	2	3	4	5	6	7
S&P 500 Index (Oct 2002 - Mar 2011)							
Mean	-0.0281	-0.0258	-0.0266	-0.0269	-0.0265	-0.0258	-0.0254
Stdev	0.1026	0.0807	0.0578	0.0467	0.0398	0.0352	0.0323
Median	-0.0620	-0.0510	-0.0408	-0.0384	-0.0336	-0.0293	-0.0248
Min	-0.1601	-0.1297	-0.1293	-0.1074	-0.1019	-0.0960	-0.0891
Max	0.3547	0.2956	0.1896	0.1360	0.1055	0.0840	0.0695
Eurostoxx 50 Index (Oct 2002 - Mar 2011)							
mean	0.0238	0.0303	0.0206	0.0148	0.0108	0.0097	0.0073
stdev	0.1619	0.1432	0.1005	0.0759	0.0606	0.0509	0.0434
median	-0.0206	0.0038	0.0032	0.0077	0.0083	0.0098	0.0092
min	-0.2389	-0.1923	-0.1510	-0.1252	-0.1088	-0.1001	-0.0862
max	0.5412	0.5467	0.3742	0.2772	0.2185	0.1792	0.1497
Nikkei 225 Index (Jan 2003 - Mar 2011)							
mean	-0.0356	-0.0234	-0.0237	-0.0245	-0.0250	-0.0247	-0.0242
stdev	0.1854	0.1543	0.1134	0.0902	0.0753	0.0646	0.0559
median	-0.0368	-0.0253	-0.0182	-0.0129	-0.0100	-0.0091	-0.0095
min	-0.2979	-0.2267	-0.1936	-0.1674	-0.1493	-0.1316	-0.1161
max	0.5850	0.5356	0.3670	0.2621	0.1997	0.1576	0.1285

Table 1: Summary Statistics: Forward Equity Yields.

Region (i)	S&P 500		EuroStoxx 50		Nikkei 225	
Maturity (n)	2	5	2	5	2	5
$\beta^0_{i,n}$	0.483	0.688	0.463	0.811	0.407	0.603
	(0.140)	(0.147)	(0.199)	(0.253)	(0.077)	(0.103)
$\beta^1_{i,n}$	1.186	0.812	1.038	0.374	1.100	1.052
	(0.779)	(0.785)	(0.547)	(0.471)	(0.230)	(0.297)

Table 2: Conditional CAPM: Estimation results using monthly returns of the conditional CAPM relationship described in Equation 9. Newey-West standard errors are in parentheses.

n	β_n	t-statistic	R^2	β_n	t-statistic	R^2	β_n	t-statistic	R^2
	S&P 500			EuroStoxx 50			Nikkei 225		
1	0.88	7.36	76%	0.93	8.28	73%	0.63	5.16	65%
2	1.09	5.87	70%	1.01	7.55	69%	0.76	5.63	65%
3	1.40	5.29	60%	1.44	7.42	69%	1.03	5.72	64%
4	1.66	4.75	54%	1.87	7.10	66%	1.29	5.61	63%
5	1.86	4.16	48%	2.29	6.78	62%	1.53	5.45	62%

Table 3: Predictability of annual dividend growth by forward equity yields, using univariate regressions with one forward equity yield of maturity n on the right-hand side. The t-statistics are computed using Hansen Hodrick (1980) standard errors.

	US		Europe		Japan	
	g	θ	g	θ	g	θ
2-year yield	80.4%	19.6%	73.3%	26.7%	61.7%	37.3%
5-year yield	72.5%	27.5%	77.7%	22.3%	77.8%	21.2%

Table 4: Variance decomposition of forward equity yields into expected dividend growth variation (g) and risk premium variation (θ).

Panel A: Consumption growth predictability by equity yields

n	Estimate	t-statistic	R^2
1	0.10	5.12	40.4%
2	0.12	5.54	38.0%
3	0.16	4.68	30.5%
4	0.18	3.73	25.7%
5	0.19	3.10	21.2%

Panel B: Consumption growth predictability by nominal bond yields

	Estimate	t-statistic	R^2
1-year	0.19	0.90	3.9%
5-year	0.65	1.83	14.1%
5-1-year	0.04	0.09	0.0%

Panel C: Consumption growth predictability by real bond yields

	Estimate	t-statistic	R^2
2-year	-0.21	-1.12	2.3%
5-year	-0.22	-0.58	0.8%
5-2-year	0.79	2.11	7.8%

Table 5: Predictability of consumption growth by forward equity yields (Panel A), nominal bond yields (Panel B) and real bond yields (Panel C) using quarterly observations between December 2002 and March 2011. The t-statistics are computed using Hansen Hodrick (1980) standard errors.

Maturity	n=1	n=2	n=3	n=4	n=5
Right hand side variables					
PC1 nominal bonds	0.297	0.291	0.336	0.366	0.369
PC1 + PC2 nominal bonds	0.311	0.306	0.335	0.366	0.370
PC1 real bonds	0.037	0.027	0.005	0.000	0.001
PC1 + PC2 real bonds	0.062	0.052	0.016	0.005	0.005
PC1 + PC2 nominal and PC1 + PC2 real bonds	0.751	0.697	0.650	0.637	0.600

Table 6: R-squared values of contemporaneous regressions of forward equity yields, with maturities n=1,...5 years on principal components of nominal and real bond yields. We use the first two principal components. We use monthly observations between October 2002 and March 2011.

Correlations

Panel A: Levels

	PC1 Eq	PC2 Eq	PC1 Nom B.	PC2 Nom B.	PC1 Real B.	PC2 Real B.
PC1 Equity	1	0	-0.56	-0.09	0.14	-0.14
PC2 Equity		1	-0.19	0.36	-0.51	0.22
PC1 Nom Bonds			1	0	0.58	0.33
PC2 Nom Bonds				1	-0.24	0.82
PC1 Real Bonds					1	0
PC2 Real Bonds						1

Panel B: Innovations

	PC1 Eq	PC2 Eq	PC1 Nom B.	PC2 Nom B.	PC1 Real B.	PC2 Real B.
PC1 Equity	1	-0.02	-0.40	-0.23	0.38	-0.12
PC2 Equity		1	0.02	-0.03	-0.28	-0.05
PC1 Nom Bonds			1	0.72	0.20	0.62
PC2 Nom Bonds				1	0.20	0.72
PC1 Real Bonds					1	0.02
PC2 Real Bonds						1

Table 7: Correlations between principal components. The second principal components are normalized with respect to their sign to be interpretable as a yield curve slope. Panel A reports correlations in levels, and Panel B describes correlations in innovations computed from a VAR(1) model for all six principal components.

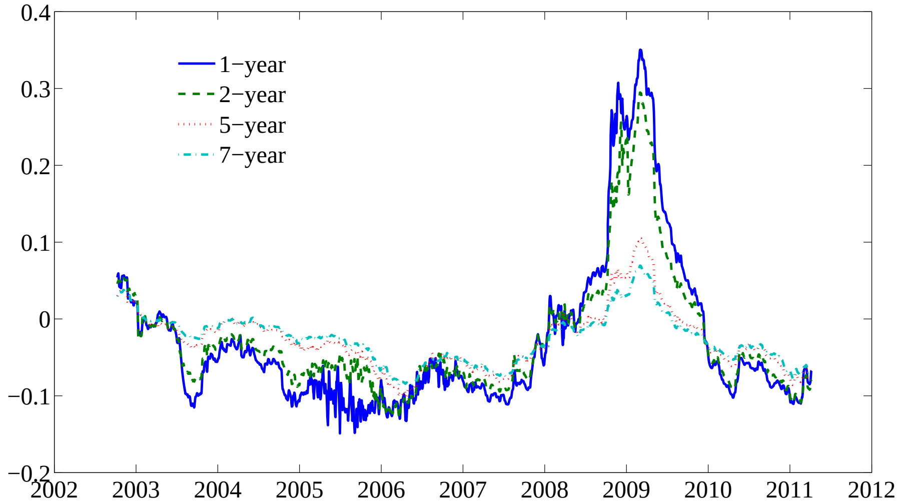

Figure 1: Forward equity yields: S&P 500 Index
The graph displays the forward equity yields $e^f_{t,n}$ for $n = 1, 2, 5$, and 7 years for t varying between October 7th 2002 and April 8th 2011.

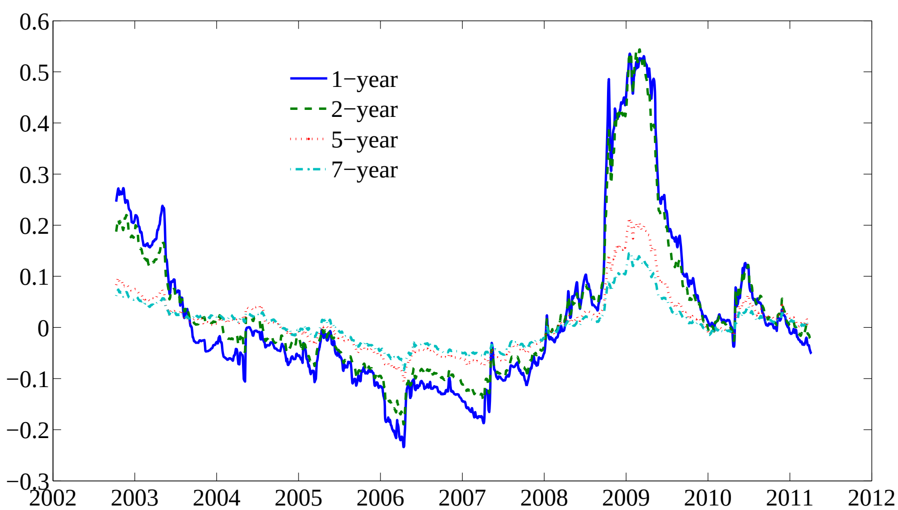

Figure 2: Forward equity yields: Eurostoxx 50 Index
The graph displays the forward equity yields $e^f_{t,n}$ for $n = 1, 2, 5$, and 7 years for t varying between October 7th 2002 and April 8th 2011.

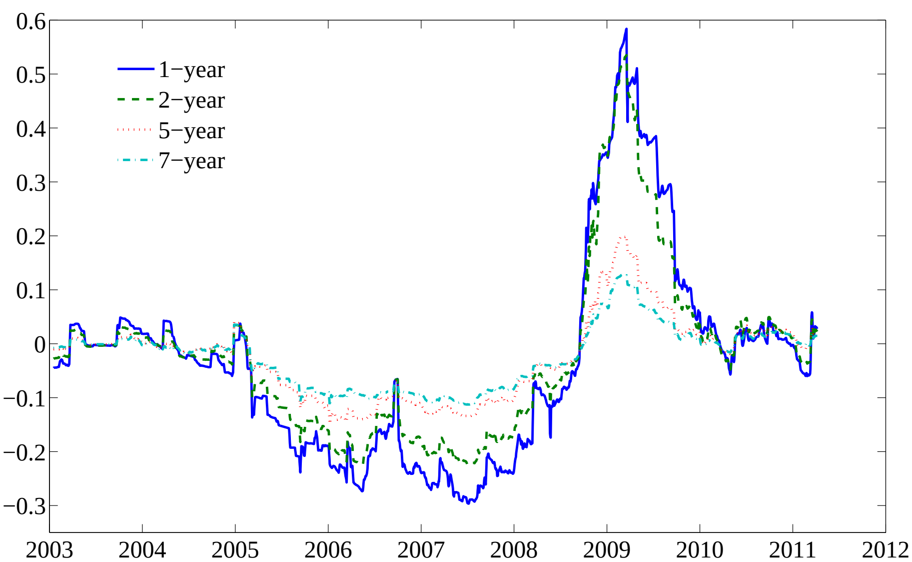

Figure 3: Forward equity yields: Nikkei 225 Index
The graph displays the forward equity yields $e^f_{t,n}$ for $n = 1, 2, 5$, and 7 years for t varying between January 14th 2003 and April 8th 2011.

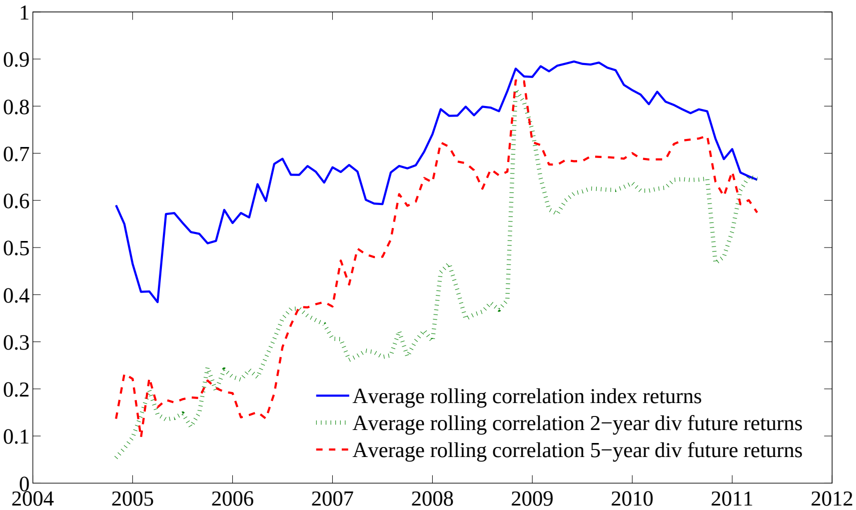

Figure 4: Average 24-month rolling correlation: $\bar{\rho}_{n,t}$
For each region, we compute 24-month rolling correlations for 2-year and 5-year dividend future returns, as well as for the index returns. We plot the average correlation across regions.

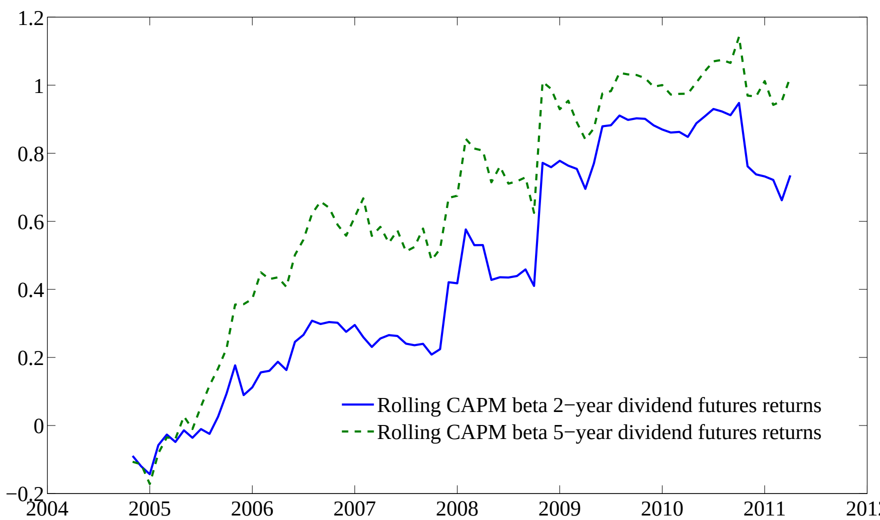

Figure 5: Average rolling CAPM beta
For each region we compute a 24-month rolling CAPM beta of the 2-year and 5-year dividend futures returns with respect to their own index returns. The graph reports the average across regions.

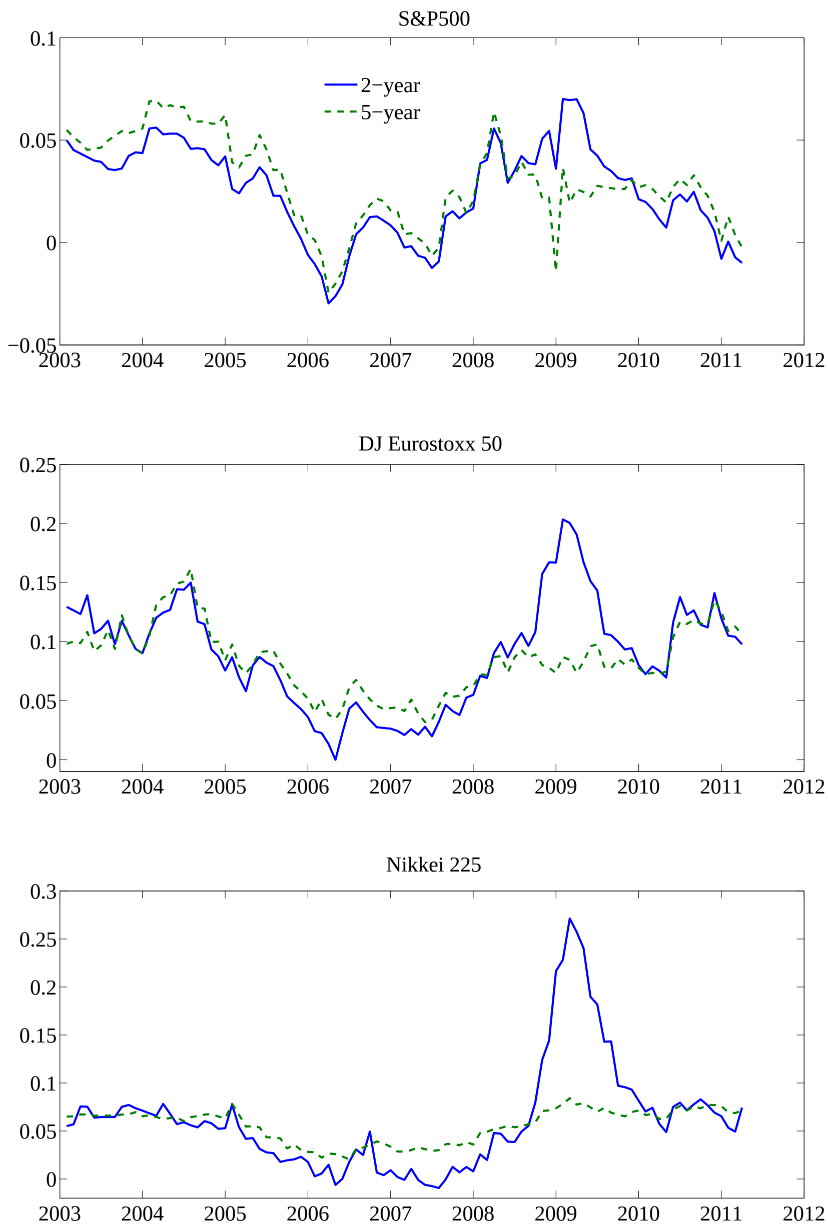

Figure 6: Risk-premium dynamics across maturities
The graph displays the risk premium component for the 2-, and 5-year forward equity yields for all three regions.

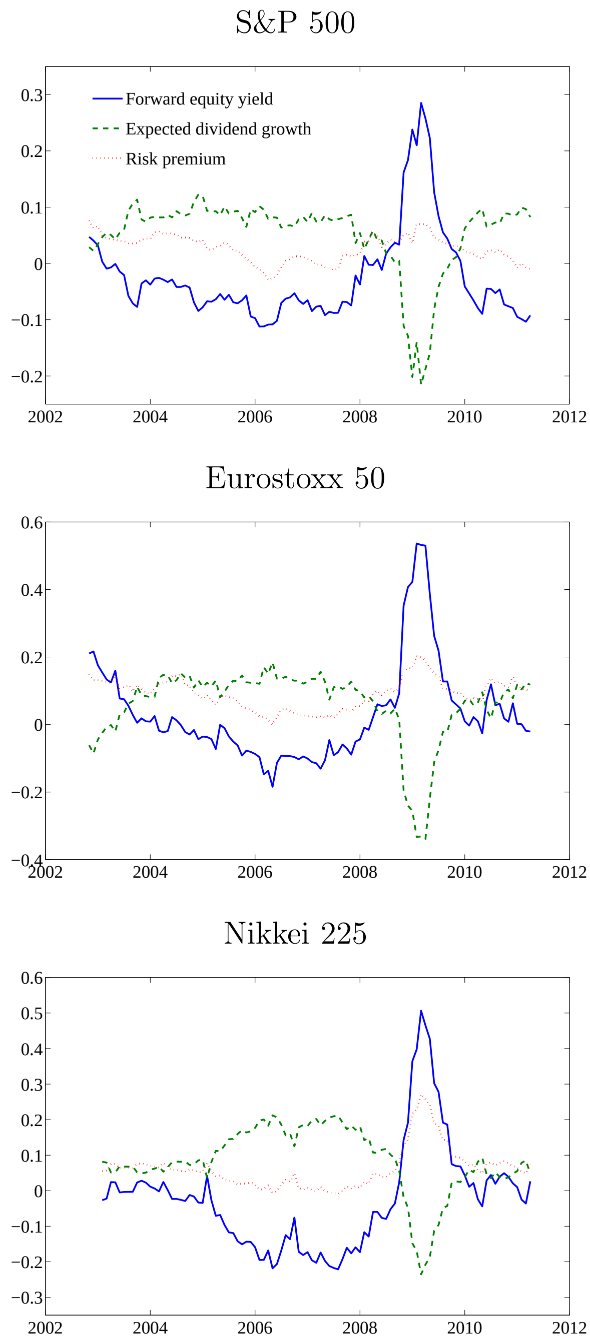

Figure 7: Decomposition of 2-year forward equity yields
The top panel decomposes the 2-year forward equity yield of the S&P 500 index into expected dividend growth $g_{t,2}$ and the risk premium component $\theta_{t,2}$. The middle and bottom panel show the same decompositions but for the Eurostoxx 50 and the Nikkei 225.

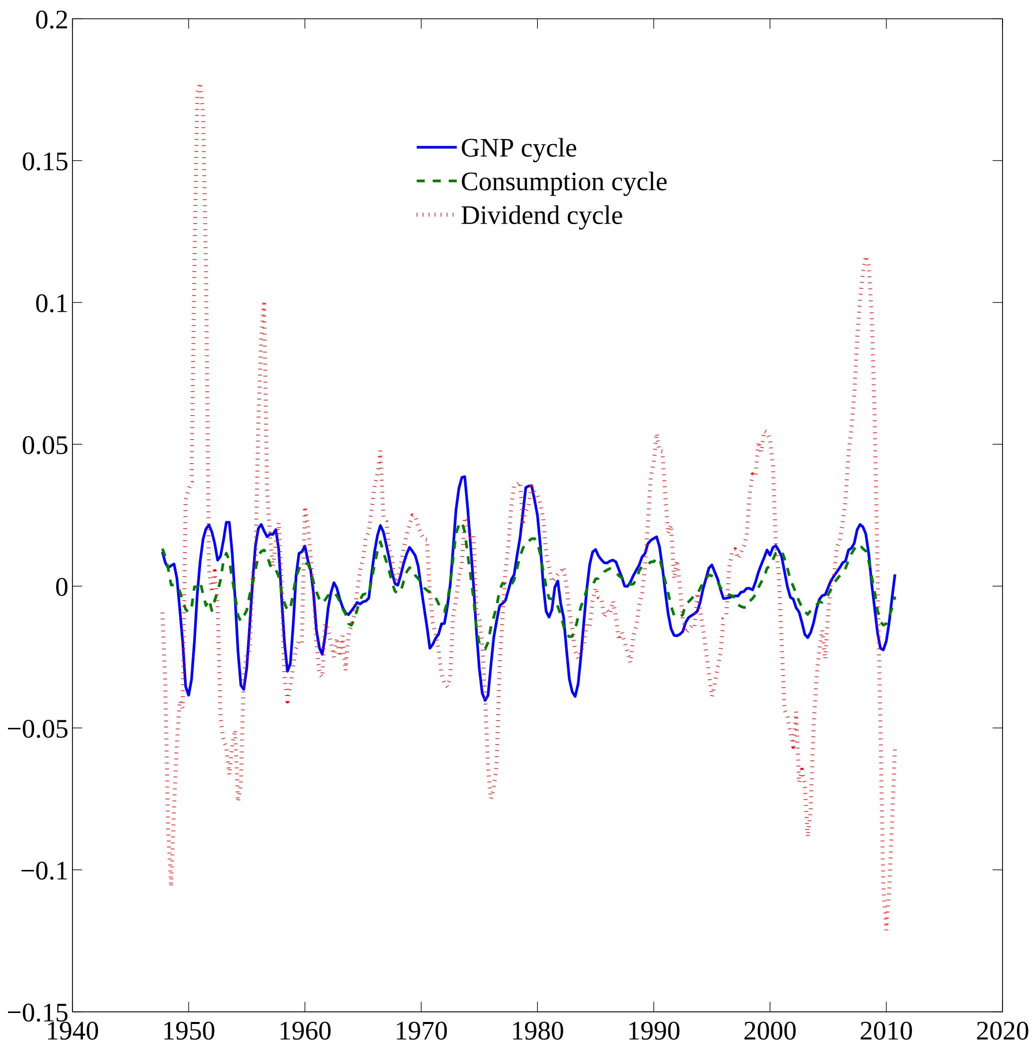

Figure 8: Cyclical components of GNP, consumption, and dividends
The graph displays the cyclical residue of Hodrick-Prescott filtered series for real GNP, real consumption (nondurables and services) and dividends.

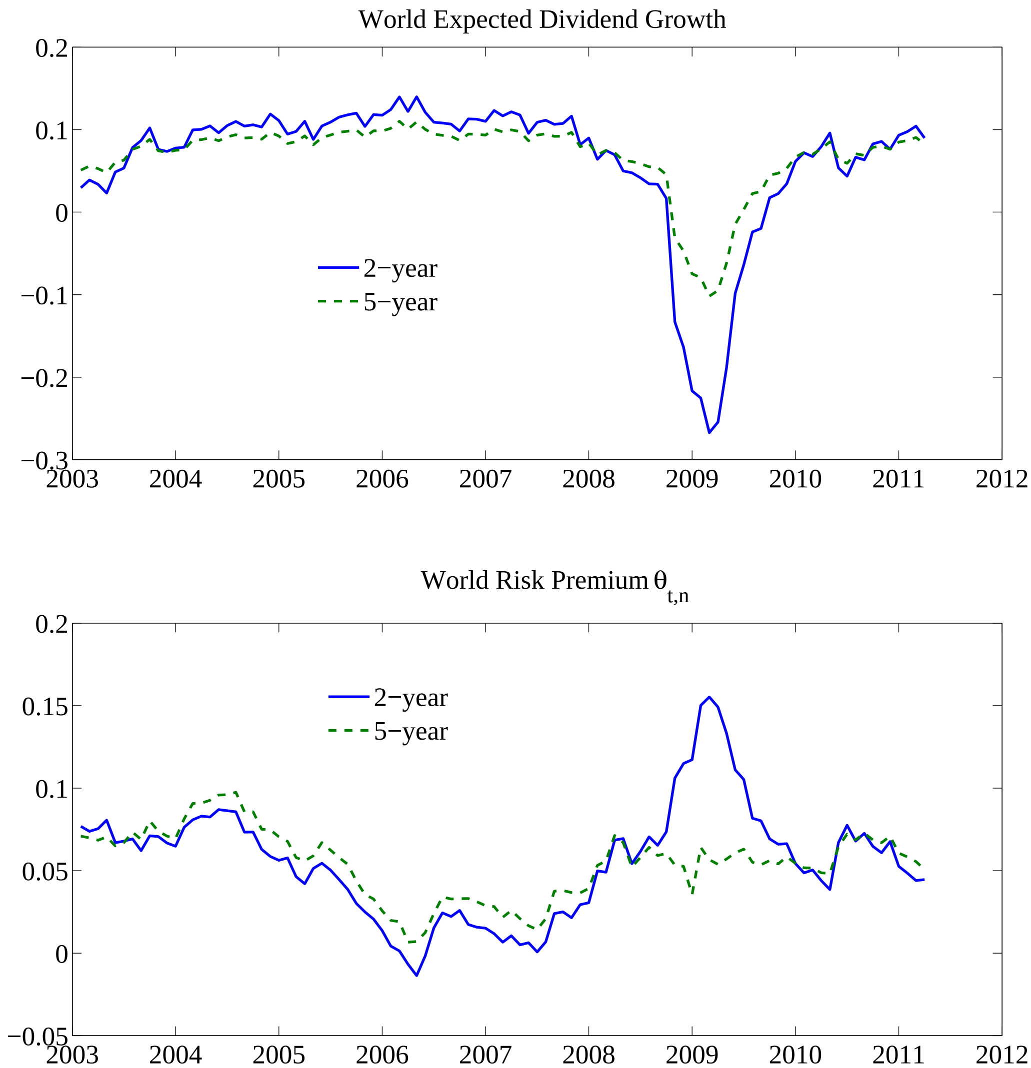

Figure 9: World Risk Premium ($\theta_{t,n}$) and Expected Dividend Growth ($g_{t,n}$)

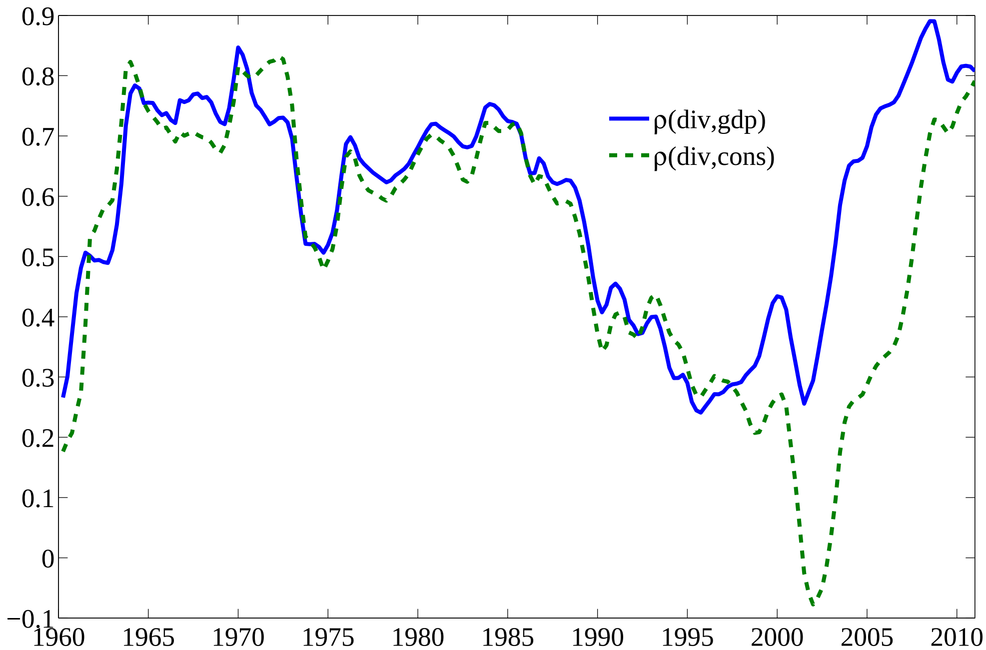

Figure 10: Rolling correlations between the cyclical components of consumption, GNP, and dividends

The graph displays the rolling correlation between the cyclical residue of Hodrick-Prescott filtered series for real GNP, real consumption (nondurables and services) and dividends. We use a 10-year window to construct the correlations.

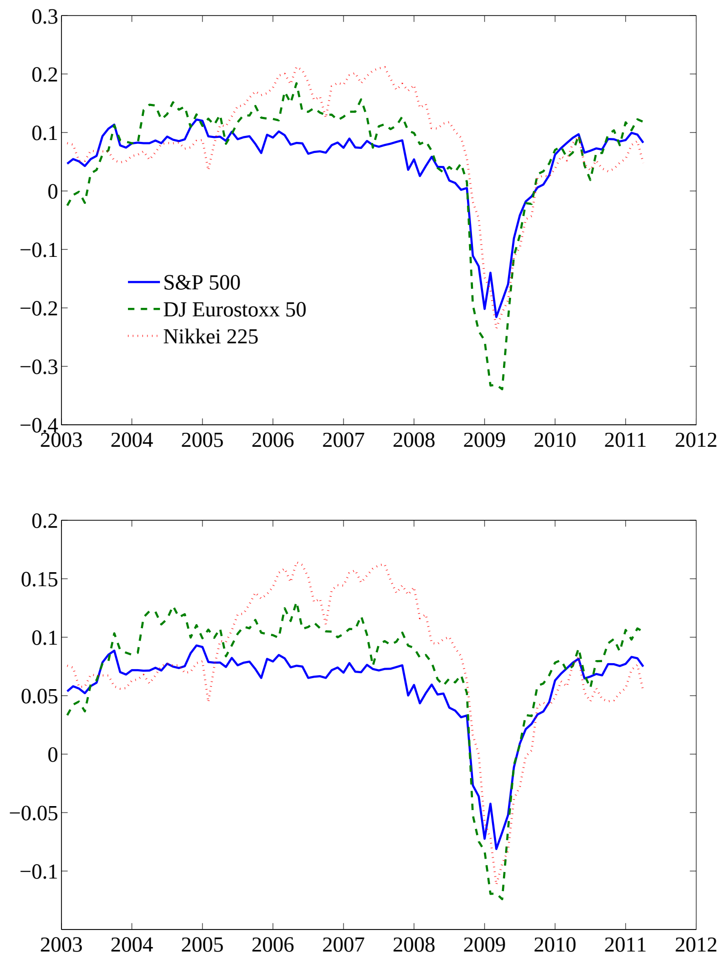

Figure 11: 2-year and 5-year expected dividend growth across regions
The graph displays the expected growth rate $g_{t,n}$ for $n = 2$ and 5 years for t varying between January 14th 2003 and April 8th 2011 for three regions: the US (as represented by the S&P 500 Index), Europe (as represented by the Eurostoxx 50 index), and Japan (as represented by the Nikkei 225 index).

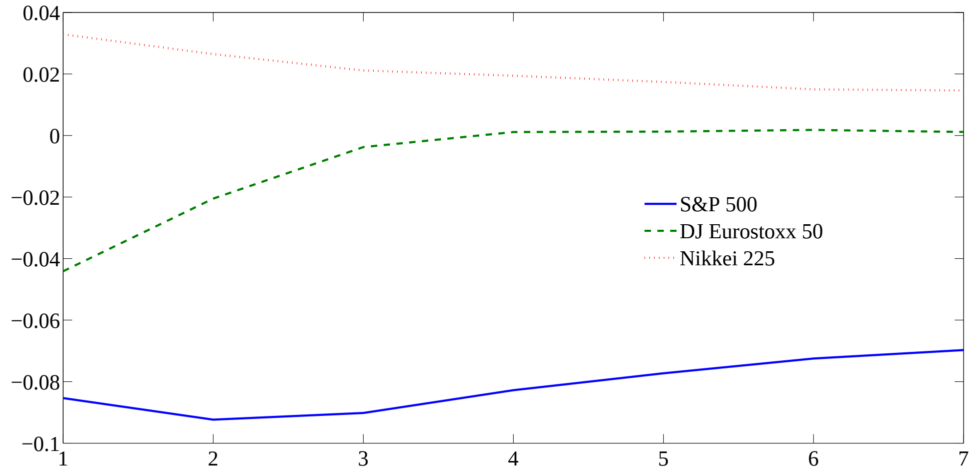

Figure 12: Term Structure of Forward Equity Yields on March 31st 2011

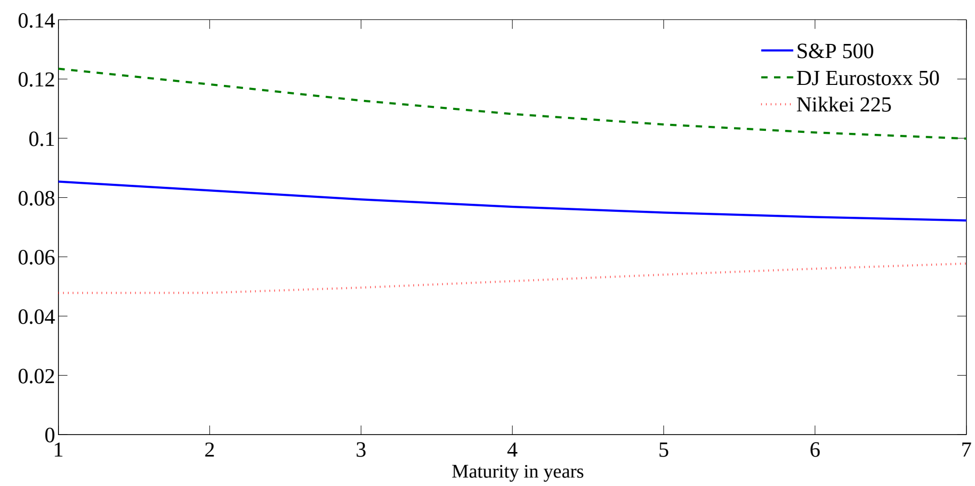

Figure 13: Term Structure of Expected Dividend Growth on March 31st 2011

A Appendix

A.1 Bayesian Model Averaging

A.1.1 Dividend Growth

In this appendix, we explore how well equity yields can be used to predict measures of economic activity such as dividend growth and consumption growth. As dividend assets started trading around the turn of the millennium, our sample is shorter than other commonly-used leading economic indicators (predictors), such as the yield spread, credit spreads, and the dividend-to-price ratio.[22] To formally assess the value forward equity yields may add relative to other predictors, we take the perspective of an economic agent forming beliefs about economic activity given the information available at a given point in time using a Bayesian model averaging (BMA) approach.[23] The economic agent forms beliefs about a set of candidate forecasting models, and has to choose how much weight to assign to each model. The BMA approach trades off a longer time series (and hence a higher accuracy of the predictive relationship) of other predictor variables, against the shorter time series of forward equity yields that appear to predict growth well.

We will explore bivariate regressions. The main reason to include two (or more) yields is that forward equity yields do not only move because of expected dividend growth variation but also because of risk premium variation. This risk premium variation can negatively affect the predictive power of each individual yield. If the risk premium variation across yields of different maturities is correlated, putting multiple yields in the regression will improve the forecasting power.[24]

We follow Fernandez, Ley, and Steel (2001) and Wright (2008) and the references therein, and consider a set of k linear models $M_1, ...M_k$. We will focus on models with two forecasting variables. Let the i^{th} linear model be given by:

$$\Delta d_{t+12} = \beta_i z_{i,t} + \varepsilon_{d,t+12}, \tag{21}$$

where z_i is the matrix of regressors for model i. The econometrician knows that one of these models is the true model, but does not know which one.

[22]See Stock and Watson (1989), Stock and Watson (2000), Stock and Watson (2003), Ang and Monika Piazzesi (2006), Faust, Gilchrist, Wright, and Zakrajsek (2011) and many others.

[23]See among others Min and Zellner (1993), Fernandez, Ley, and Steel (2001), Cremers (2002) and Wright (2008).

[24]See also Fama (1984) for exchange rates and Stambaugh (1988) and Cochrane and Piazzesi (2005) for bonds.

Let $\pi(M_i)$ denote the prior probability of model i being the true model. Conditional on seeing the data up to time s, (denoted by X_s) for dividend growth and the predictor variables, the posterior probability of model i being the true model is given by:

$$\pi(M_i|X_s) = \frac{\pi(X_s|M_i)\pi(M_i)}{\sum_{i=1}^{k}\pi(X_s|M_i)\pi(M_i)}. \tag{22}$$

In January 1954, we start with a flat prior over all models, in the sense that we assign equal probability to each model:

$$\pi(M_i) = \frac{1}{k}. \tag{23}$$

We make the following assumptions regarding the prior distributions of the parameters. For β, we take the natural conjugate g-prior specification (Zellner (1986)), so that the prior for β conditional on the variance of the error term σ^2 is $N(0, \phi\sigma^2(X'X)^{-1})$, where ϕ is a shrinkage parameter. For σ, we assume the improper prior that is proportional to $1/\sigma$. Finally, motivated by the fact that we use overlapping data, we use an MA-structure for ε_t:

$$\text{cov}(\varepsilon_t, \varepsilon_{t-j}) = \sigma^2\frac{h-j}{h}, \tag{24}$$

where h measures the amount of overlap in the data, that is, $h = 12$ for monthly data, and $h = 4$ for quarterly data (Wright (2008)). Under these assumptions, the likelihood of the data up until time s, denoted by X_s, given the model, is given by:

$$\pi(X_s|M_i) = \frac{\Gamma(s/2)}{\sqrt[2]{\pi}}(1+\phi)^{-p/2}H_i^{-s/h}, \tag{25}$$

where $\Gamma(\cdot)$ is the gamma function, p is the number of regressors, and H_i^2 is given by:

$$H_i^2 = \Delta d'\Delta d - \Delta d' z_i(z_i'z_i)^{-1}z_i'\Delta d\frac{\phi}{1+\phi}, \tag{26}$$

where $\Delta d \equiv (\Delta d_1, ..., \Delta d_s)'$ is the vector of realized dividend growth rates up until time s (the subscript s is dropped for ease of notation), and z_i is the matrix with the regressors of model i up until time s.

The parameter p can be interpreted as a penalty on the number of regressors, and a higher number of p will lead to a lower likelihood value. We set the shrinkage parameter ϕ to 1, following Wright (2008).

Without loss of generality, we demean all variables on the right-hand side of the equation. If for a certain value of s the sample is such that the predictors do not exist in the beginning of the sample, but do exist later in the sample, the parameter p is set to 2, and a maximum mean-squared error is added to the likelihood for the missing observations. The latter is equivalent to setting the value of the predictor variables equal to 0 for these periods. In this way we take a conservative approach towards the value added of forward equity yields when predicting dividend growth. Put differently, this assumption works against the model with forward equity yields, and relaxing this assumption would make our findings stronger.

We consider five different models using data between 1954 and 2011. The first four models have 2 predictor variables and the fifth model has no predictor variables, that is, under model 5, dividends follow a random walk. The first model ($i = 1$) uses two forward equity yields as the predictors: the 2-year ($n = 2$) and the 5-year ($n = 5$) yields:

$$z_{1,t} = \left[e^f_{t,2} \;\; e^f_{t,5}\right]'. \tag{27}$$

The second model ($i = 2$) has two bond yields (the 2-year and the 5-year bond yield):

$$z_{2,t} = \left[y_{t,2} \;\; y_{t,5}\right]'. \tag{28}$$

The third model has the 2-year bond yield and the credit spread, and the fourth model has the dividend yield and the credit spread. Adding two real bond yields as a model leaves our results unaffected and the posterior probability of this model converges to 0. For ease of presentation, we focus on the five models above.

For models 2, 3, 4, the data exists for the full sample period, that is, every value of s. For forward equity yields, the data starts in October 2002, indicated by the vertical black line. Even though for forward equity yields there are many subsamples X_s where no data is available, we still set $p = 2$ for every value of s. In other words, forward equity yields do receive the penalty for 2 regressors, despite the fact that for all subsamples before 2002 no data is available.[25] For the fifth model where dividends are a random walk, we set $p = 0$ as there are no regressors for any subsample. Because the random walk model does not receive a penalty for including regressors, it can outperform the other models despite having a larger mean-squared error.

The results are summarized in Figure 14. The figure shows that an economic agent who in 1954 assigns a probability of 0.20 to each of the four models, in 2011 has a updated probability of about 0.9 that the model with two forward equity yields is the right model to

[25]As before, this assumption works against the model with forward equity yields. Relaxing this assumption would make our findings stronger.

predict dividend growth with, despite its very short sample and hence its large uncertainty regarding the predictive relationship.

Finally, we compare the model without predictors (a random walk for dividends) with the model of two forward equity yields. That is, we perform the thought experiment where a real-time investor has to choose between a model in which dividend growth is unpredictable, and a model where dividend growth is predictable by two forward equity yields. The investor knows that one of these two models is the true model. The results are presented in Figure 15. The vertical line shows the point at which data for forward equity yields becomes available (October 2002). Because the penalty parameter p is set to a value of 2 for the model with two forward equity yields and to 0 for the random walk model, and the prediction error is equal for both models up until 2002, the posterior probability for the random-walk model is higher than that for the forward equity yields model to the left of the vertical line. However, as soon as data for forward equity yields becomes available, this model quickly takes over. At the end of our sample the posterior probability of the model with two forward equity yields approaches the upper bound of 1, suggesting that an agent who has to choose between unpredictable dividend growth and dividend growth that is predictable by two forward equity yields, will choose the latter.

A.1.2 Consumption Growth

We then apply the BMA approach to consumption growth. We use the exact same setup as in Section A.1.1, but now use consumption growth as the left-hand-side variable. As before, we take a conservative approach with respect to forward equity yields as predictors of consumption growth by setting the penalty parameter $p = 2$ even for subsamples where no data is available.

First, we compare the model without predictors (a random walk for consumption) with the model of two forward equity yields. That is, we perform the thought experiment where an agent has to choose in real time between a model in which consumption growth is unpredictable, and a model where consumption growth is predictable by two forward equity yields. The investor knows that one of these two models is the true model. The results are presented in Figure 16. As before, the vertical black line shows the point at which data for forward equity yields becomes available (2002). Because the penalty parameter p is set to a value of 2 for the model with forward equity yields and to 0 for the random walk model, and the prediction error is equal for both models up until 2002, the posterior probability for the random walk model is higher than that for the forward equity yields model before 2002. However, as soon as data for forward equity yields becomes

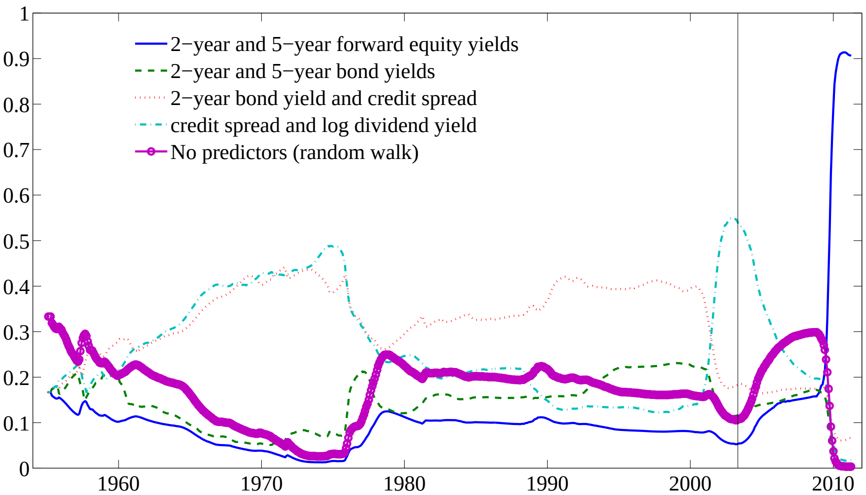

Figure 14: Posterior probabilities of the Bayesian model averaging approach: Dividends
The graph displays the posterior probabilities of five predictive models of annual dividend growth, using monthly data. The first four models all have two predictor variables ($p = 2$). The first model uses two equity yields (2-year and 5-year) to predict dividend growth, the second model uses two bond yields, the third model has the 2-year bond yield and the credit spread, and the fourth model uses the dividend yield and the credit spread. The fifth model has no predictor variables ($p = 0$), which implies a random walk for dividends.

available, this model takes over. At the end of our sample the posterior probability of the model with two forward equity yields increases from 0.33 to 0.60, and the random walk model changes from a probability of 0.67 to 0.40. Note that this change is not as large as the change for dividend growth in the previous section, but it does suggest that forward equity yields have some value in predicting consumption growth.

We then include the other three models with two regressors (two bond yields, credit spread and short-maturity bond yield, and credit spread and dividend yield). The results are presented in Figure 17. Recall that for all the other predictors the data exists for the whole sample period. The figure shows that for the early part of the sample, the posterior probability of the other models increases substantially, and the probability that the forward equity yields model is the correct one decreases to as low as 4.9%. After 2002, when data for forward equity yields becomes available this probability more than doubles to 12.8%. It thereby outperforms both the model with two bond yields as well as the random walk model. However, given the success of the other models in the earlier period, the data sample of forward equity yields is too short to outperform the models that include the credit spread, in the sense that these models are assigned a higher posterior probability in 2011.

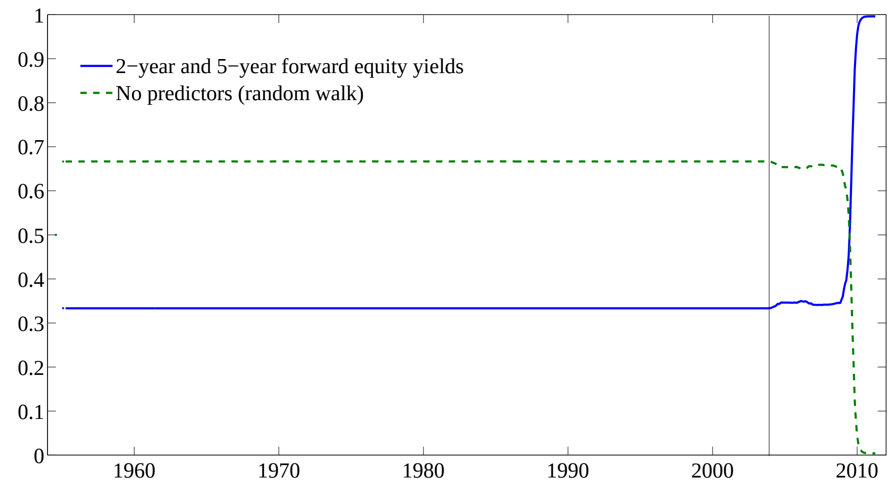

Figure 15: Posterior probabilities of the Bayesian model averaging approach: Dividends
The graph displays the posterior probabilities of two predictive models of annual dividend growth, using monthly data. The first model uses two equity yields (2-year and 5-year) to predict dividend growth ($p = 2$). The second model has no predictor variables ($p = 0$), which implies a random walk for dividends.

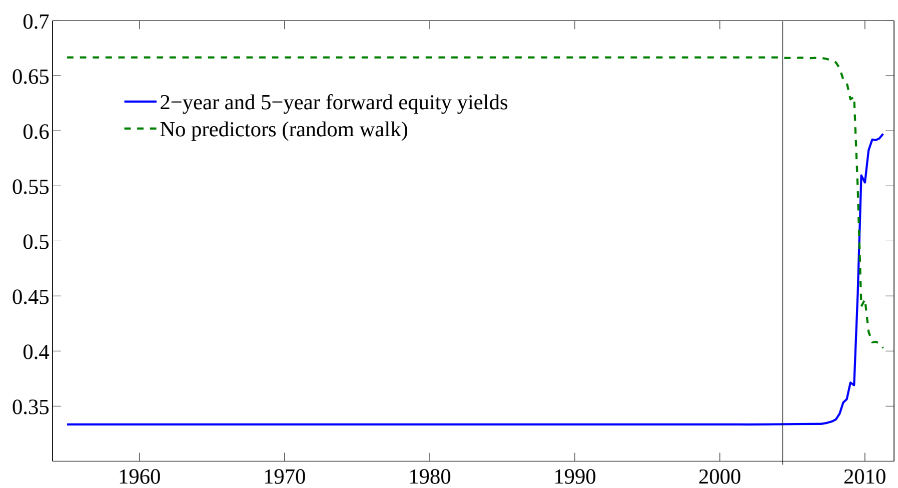

Figure 16: Posterior probabilities of the Bayesian model averaging approach: Consumption
The graph displays the posterior probabilities of two predictive models of annual consumption growth, using monthly data. The first model uses two forward equity yields (2-year and 5-year) to predict dividend growth ($p = 2$). The second model has no predictor variables ($p = 0$), which implies a random walk for consumption.

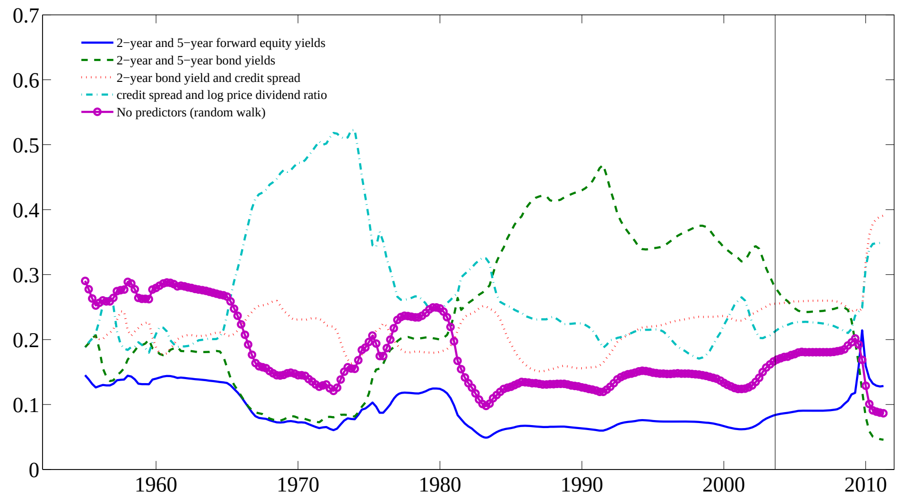

Figure 17: Posterior probabilities of the Bayesian model averaging approach: Consumption The graph displays the posterior probabilities of five predictive models of annual consumption growth, using monthly data. The first four models all have two predictor variables ($p = 2$). The first model uses two forward equity yields (2-year and 5-year) to predict consumption growth, the second model uses two bond yields, the third model has the 2-year bond yield and the credit spread, and the fourth model uses the dividend yield and the credit spread. The fifth model has no predictor variables ($p = 0$), which implies a random walk for consumption.

A.2 Arithmetic vs Geometric Yields and Growth Rates

As noted in the main text, we also compute summary statistics for arithmetic forward equity yields, defined as $\exp(e^f_{t,n}) - 1$. The results are summarized in Table 8.

Maturity in years	1	2	3	4	5	6	7
S&P 500 Index (Oct 2002 - Mar 2011)							
Mean	-0.0224	-0.0223	-0.0248	-0.0256	-0.0254	-0.0248	-0.0246
Stdev	0.1110	0.0856	0.0589	0.0468	0.0395	0.0348	0.0317
Median	-0.0603	-0.0499	-0.0400	-0.0378	-0.0330	-0.0289	-0.0245
Min	-0.1480	-0.1216	-0.1213	-0.1019	-0.0969	-0.0915	-0.0852
Max	0.4258	0.3439	0.2088	0.1457	0.1113	0.0877	0.0720
Eurostoxx 50 Index (Oct 2002 - Mar 2011)							
mean	0.0385	0.0421	0.0261	0.0178	0.0127	0.0110	0.0083
stdev	0.1898	0.1698	0.1115	0.0811	0.0635	0.0527	0.0446
median	-0.0208	0.0032	0.0031	0.0074	0.0083	0.0098	0.0093
min	-0.2125	-0.1749	-0.1402	-0.1176	-0.1031	-0.0952	-0.0826
max	0.7181	0.7275	0.4538	0.3195	0.2442	0.1962	0.1615
Nikkei 225 Index (Jan 2003 - Mar 2011)							
mean	-0.0171	-0.0105	-0.0168	-0.0201	-0.0219	-0.0223	-0.0223
stdev	0.2038	0.1715	0.1190	0.0915	0.0751	0.0639	0.0551
median	-0.0361	-0.0250	-0.0180	-0.0129	-0.0100	-0.0090	-0.0095
min	-0.2576	-0.2028	-0.1760	-0.1541	-0.1386	-0.1233	-0.1096
max	0.7950	0.7084	0.4434	0.2996	0.2210	0.1707	0.1371

Table 8: Summary statistics forward equity yields using arithmetic (as opposed to geometric) yields.

Finally, in Table 9 we report predictive regression results of arithmetic dividend growth rates on lagged arithmetic forward equity yields:

$$\exp\left(\Delta d_{t+12}\right) = \alpha_n + \beta_n \exp(-e^f_{t,n}) + \varepsilon_{d,t+12}. \tag{29}$$

	S&P 500			EuroStoxx 50			Nikkei 225		
n	β_n	t-statistic	R^2	β_n	t-statistic	R^2	β_n	t-statistic	R^2
1	0.91	7.52	75%	1.04	8.01	74%	0.67	5.06	65%
2	1.11	5.84	68%	1.15	7.24	70%	0.83	5.56	65%
3	1.36	5.02	57%	1.55	6.93	68%	1.08	5.66	64%
4	1.59	4.45	51%	1.95	6.47	64%	1.32	5.56	64%
5	1.75	3.90	45%	2.29	6.13	61%	1.56	5.43	63%

Table 9: Predictability of annual dividend growth (arithmetic) by lagged forward equity yields, using univariate regressions with one forward equity yield of maturity n on the right-hand side. We use arithmetic growth rates and yields. The t-statistics are computed using Hansen Hodrick (1980) standard errors.