Essays on the Temporal Structure of Risk

by

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Business Administration
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Dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy
in the Department of Business Administration
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ABSTRACT

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Abstract

I provide new evidence on the properties of the temporal structure of risk, which answers whether more distant claims to macroeconomic growth are more or less risky than near-term claims. In the first chapter, I use replication and no-arbitrage to estimate within-firm variation in equity expected returns across horizons. I demonstrate that a low dimensional set of returns and state variables, all characteristics of liquid, exchange-traded equity securities, provide a close replication of claims to firm capital gains at different horizons. Calculating returns from the no-arbitrage prices of these claims, I show that the term structure of risk premia is unconditionally upward-sloping for commonly used test assets like the market and book-to-market sorted portfolios.

In joint work with Ravi Bansal, Dongho Song, and Amir Yaron in the second chapter, we use traded equity dividend strips from U.S., Europe, and Japan from 2004-2017 to study the slope of the term structure of equity dividend risk premia. In the data, our robust finding is that the term structure of dividend risk premia (growth rates) is positively (negatively) sloped in expansions and negatively (positively) sloped in recessions. We develop a consumption-based regime switching model which matches these robust data-features and the historical probabilities of recession and expansion regimes. The unconditional population term structure of dividend risk premia in the regime-switching model, as in standard asset pricing models (habits and long-run risks), is increasing with maturity. In sum, our analysis shows that the empirical evidence in dividend strips is consistent with a positively sloped term structure of dividend risk-premia as implied by standard asset pricing models.

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List of Abbreviations

BVAR Bayesian Vector Autoregression

CEPR Centre for Economic Policy Research

CRSP Center for Research in Security Prices

FED United States Federal Reserve Board

GDP Gross Domestic Product

GMM Generalized Method of Moments

HAC Heteroskedasticity and Autocorrelation Consistent

LSP Long Sample Predictor

NBER National Bureau of Economic Research

OTC Over-the-Counter

RMSE Root Mean Squared Error

SDF Stochastic Discount Factor

SSP Short Sample Predictor

SVVAR Stochastic Volatility Vector Autoregression

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I thank my committee members Ravi Bansal, Anna Cieslak, David Hsieh, and Suresh Nallareddy, and especially Ravi Bansal and Anna Cieslak for their extensive feedback, advice, and assistance.

Chapter 2 of this dissertation is based on joint work with Ravi Bansal (Fuqua School of Business, Duke University), Dongho Song (Carey Business School, Johns Hopkins University), and Amir Yaron (The Wharton School, University of Pennsylvania, and Bank of Israel).

Introduction

Do more distant claims to macroeconomic growth carry higher or lower risk premia than nearer term claims? This question, whether the temporal structure of risk is upward or downward-sloping, is at the core of an active debate in asset pricing and macro-finance. The answer is important for corporate planning, macroeconomic modeling and analysis, and asset pricing research because it reveals the correct term-specific discount rates for project cash flows and allows researchers to compare models with different term structure predictions against each other. An active debate on the slope of the term structure of equity risk premia in particular has arisen because many standard macro-finance models, e.g. [20] (habits), [9] (long run risks), and [30] (variable rare disasters) predict an upward-sloping or flat term structure, while recent research argues that the term structure is downward-sloping in the data and inconsistent with these predictions, e.g. [14], [15], and [17]. One limitation to the conduct of research on the term structure is the relatively small time series span of the data available to test the dividend risk premium term structure facts directly, which starts in 1996 (for option data) or 2002 (for traded dividend strips). In this dissertation I present two essays that shed new light on the term structure of equity risk premia by developing new methods to use alternative datasets to learn about the term structure and re-examining the consistency of the existing data with standard models.

In Chapter 1 I provide new evidence on the properties of the term structure of equity risk premia by using replication and no-arbitrage to estimate within-firm variation in expected returns across horizons. I demonstrate that a low dimensional set of returns and state variables provide a close replication of claims to firm capital gains at different horizons. Calculating returns from the no-arbitrage prices of these claims, I show that the term structure of risk premia is unconditionally upward-sloping for commonly used test assets like the market and book-to-market sorted portfolios. I derive nonparametric upper bounds on the prices of the replication errors to argue that these results are robust to the pricing of the basis risk of the replication. My method extends the literature by expanding both the span and scope of the data available to test term structure relationships while using prices of assets that are highly liquid relative to the existing derivative datasets. My results are qualitatively consistent with the existing derivatives-based evidence when restricted to the same sample period.

In joint work in Chapter 2 we use traded equity dividend strips from U.S., Europe, and Japan from 2004- 2017 to study the slope of the term structure of equity dividend risk premia. In the data, a robust finding is that the term structure of dividend risk premia (growth rates) is positively (negatively) sloped in expansions and negatively (positively) sloped in recessions. We develop a consumption-based regime switching model which matches these robust data-features and the historical probabilities of recession and expansion regimes. The unconditional population term structure of dividend-risk premia in the regime-switching model, as in standard asset pricing models (habits and long-run risks), is increasing with maturity. The regime-switching model also features a declining average term structure of dividend risk-premia if recessions are overrepresented in a short sample, as is the case in the data sample from Europe and Japan. In sum, our analysis shows that the empirical evidence in dividend strips is entirely consistent with a positively sloped term structure of dividend risk-premia as implied by standard asset pricing models.

Chapter 2 highlights the importance of adjusting methods of inference to account for the limitations of a dataset. The strips dataset is short (about 14 years) and the markets for dividend strips are highly illiquid, which motivate our focus on the well-measured conditional moments of the data rather than the sample means and on the hold to maturity risk premia, respectively. Previous studies using these datasets do not take these issues into account, and reach different conclusions as a result. The methods I introduce in Chapter 1 also directly address these issues by relying solely on highly liquid exchange traded equity data that has a long history, more than 50 years of additional time series span. In sum, the essays in this dissertation provide new, highly robust evidence that the term structure of equity returns and risk premia is upward-sloping in contrast to the conclusions of the existing literature and highlight the importance of documenting and addressing the weaknesses and strengths of a new dataset when applying it to economic inference. Chapter 2.6 summarizes these findings and concludes.

Chapter 1

The Term Structures of Equity Risk Premia in the Cross Section of Equities

1.1 Introduction

What is the slope of the term structure of equity risk premia?[1] The term structure of equity expected returns provides a powerful set of moments to test the predictions of asset pricing models, which drives an active debate on its slope. A rapid expansion of the literature on risk premium term structures is growing out of the observation that market derivative prices may support a downward-sloping term structure of equity risk premia in conflict with the implications of many general equilibrium asset pricing theories. A significant challenge in this debate is the limited time series span and cross-sectional scope of the data available to directly test the equity term structure slope. I extend the literature by proposing a method to estimate the prices of claims to firm cash flows at different horizons via replication and no arbitrage. The benefit of my method is a large reduction in the limitations of the existing data: a 50 year increase in span and a coverage of any cross-section of interest, all while relying on relatively liquid equity security prices rather than derivatives. I find that the evidence from the replication supports more distant claims within the same firm carrying higher risk premia than short term claims, in contrast to much of the empirical literature and consistent with

[1] I am grateful to participants at the Fuqua School of Business Finance lunch seminar series, Ravi Bansal, Anna Cieslak, Andrei Goncalves, David Hsieh, Lukas Schmid, and Michael Weber for their valuable feedback on Chapter 1. I also thank seminar participants at the University of Michigan (Ann Arbor), University of Wisconsin (Madison), and the Federal Reserve Board (D.C.) for their feedback on this research.

the qualitative predictions of many general equilibrium asset pricing theories.

I replicate the payoffs of claims to a firm's capital gains and show that the no-arbitrage prices of the replicating portfolios can be used to test the slope of the risk premium term structure. First, I replicate the capital gains of portfolios in the cross-section. I show that three variables - portfolio returns, portfolio price to dividend ratios, and their interaction - are sufficient to replicate the capital gains of the market and a variety of cross sectional test assets with R-squared values greater than 99% at horizons up to 5 years. Second, I compute the price of the replicating portfolio, which is known at each date because the price of each of the replicating variables is known. This price is, up to the value of the basis risk, the value of a claim to the continuation value of the firm at a given horizon, which I refer to as a continuation claim. I demonstrate that nonparametric asset pricing bounds on the price of the basis risk of the replication indicate error pricing is unlikely to impact my qualitative conclusions. Next, I conduct the replication and pricing for one year ahead, one year closer continuation claims. This allows me to construct a time series of realized annual holding period returns to continuation claims at various horizons because these returns are simply the one period ahead, one period closer claim price divided by the current claim price. I use these realized returns to test whether distant claims carry higher or lower risk premia than near-term claims.

I focus on claims to the continuation value of the firm, its terminal value after a set number of periods, scaled by the current firm price. I demonstrate in Section 1.2 that all the implications of a model for the term structure can be captured equivalently by either the stripped dividend claims or the continuation claims at various horizons. This is because both sets of claims are merely different divisions of the firm value across future horizons, and so the two term structures are linked directly by simple identities. My method closely replicates the price of continuation claims with liquid assets and a limited set of factors, yielding highly accurate estimates of the returns to continuation claims. The close relationship between dividend and continuation claims allows me to estimate the implied mean returns of cumulative dividend claims and evaluate the dividend risk premium term structure as well, permitting direct comparison to existing research.

I show that the time series of realized continuation claim returns constructed using my method support continuation claims carrying higher risk premia than both the asset and other continuation claims at shorter horizons. Both of these results imply an upward sloping risk premium term structure, and the results hold for all horizons for virtually all portfolios in the most commonly analyzed cross-sections. I also demonstrate that early dividend claims carry lower risk premia than the asset and that the earliest dividend claims have lower risk premia than more distant dividend claims. Both of these results imply an upward sloping term structure of risk premia as well. This is in contrast to previous work, which finds that early dividend strip derivatives have higher returns than the asset and that firms which deliver cash flows early tend to earn higher returns in the cross-section. I find that the difference between my results and the existing literature can be explained by the expansion of the span of the data provided by my method. My risk premium estimates are qualitatively consistent with existing work when restricted to the sample where dividend strip derivatives are available.[2]

[2]My approach and results also differ starkly from existing cross-section based term structure inference because I focus on within-firm rather than between-firm variation in risk premia. I directly estimate the object of interest, the term structure of claim prices, rather than an implied term structure based on between-firm risk premium variation. I show in Appendix A.4 that without maintaining the assumption that there are no differences in cash flow risk between firms, between-firm differences in risk premia do not identify the term structure of risk premia within any firm or for the market. By directly estimating the object of interest, the

The remainder of the chapter proceeds as follows. The next section briefly reviews the existing theoretical and empirical literature on the term structure of equity returns. Section 1.2 establishes the core relationships between the prices of dividend and continuation claims, describes the empirical method, and shows how it functions in an illustrative theoretical environment. Section 1.3 describes the data used in this study and implementation of the method, while Section 1.4 presents and discusses the core results for the market and the book-to-market sorted cross-section of equities, and Section 1.5 concludes.

1.1.1 Existing Research

The recent expansion of research on the term structure of risk premia is in part being driven by the conflict of option and traded strip-based data with existing general equilibrium consumption-based asset pricing theory. Among others, the habits model of Campbell and Cochrane [20], the long run risks model of Bansal and Yaron [10], and extensions of the rare disasters model of Barro and Ursua [11] generate upward sloping or flat term structures of risk premia, volatility, or Sharpe Ratios.[3] This is a result of the core economic mechanism that allows the models to generate large equity risk premia. Resolving this apparent conflict would require altering the mechanism or introducing first order risks present in traded equity and not in the consumption claim. Importantly, dividend strip premia and consumption premia need not follow the same pattern if dividend beta to consumption risk changes by horizon, a point raised by both Croce, Lettau, and

prices of claims at different horizons, while allowing for firm and term-specific heterogeneity, I am able to bypass this identification issue.

[3]Extensions of these models, including Wachter [58], Drechsler and Yaron [26], Bansal, Kiku, Shaliastovich, and Yaron [6], and Gabaix [30] share at least some of these characteristics: an upward-sloping term structure of risk premia, volatility, or Sharpe Ratios. Hansen [38], Backus, Boyarchenko, and Chernov [3], and Piazzesi, Schneider, and Tuzel [51] all investigate further the implications of various asset pricing models for the term structure of returns.

Ludvigson [25] and Belo, Collin-Dufresne, and Goldstein [12].

Investigating macroeconomic causes of a disconnect between dividend and consumption term structures is an active area of research. Hasler and Marfe [43] examine how recession and recovery may affect the term structure, and Ai, Croce, Diercks, and Li [1] introduce a production-based economy in which dividend strips carry a different pattern of risks by horizon than consumption claims. Andreis, Eisenbach, and Schmalz [2] investigate the link between time variation in volatility and variation in risk preferences by horizon. Cointegration of a more volatile quantity, like dividends, with a less volatile macroeconomic variable like consumption can result in a downward-sloping or non-monotonic term structure; stationary leverage policies as in Belo, Collin-Dufresne, and Goldstein [13] can generate such an environment. Goncalves [33] shows that reinvestment risk can alter or invert the slope of the dividend risk premium term structure. Information and learning channels can also affect the term structure of returns: Hasler, Khapko, and Marfe [42] show how learning can increase risk premia overall while driving a downward-sloping term structure of equity returns and an upward-sloping term structure of bond risk premia.

The literature examining the implications of these models for the cross-section is also extensive and often relies on substantial differences in cash flow risk between firms in the cross-section to generate risk premium differences, as in Bansal, Dittmar, and Lundblad [5] and Hansen, Heaton, and Li [39]. I build on the latter of these, in which the authors estimate term structures implied by matching the cross-section in structural and vector autoregression models of the stochastic discount factor.[4] In contrast to Hansen, Heaton, and Li [39], I introduce a statistical

[4]My work is also closely related to Menzly, Santos, and Veronesi [49], Lettau and Ludvigson [45],

method for investigating the term structure without appealing to a specific model of the stochastic discount factor.

Early work on the relationship between equity return term structures and the cross section in Lettau and Wachter [46, 47] assumes no differences in cash flow risks across the cross-section in order to isolate the role of the timing of cash flows as a source of variation in risk premia. Assuming no cash flow risk differences in the cross-section allows differences in risk premia between firms with different cash flow timing to identify the term structure slope within firms. More recently, Weber [59] uses this assumption to show that firms with a low cash flow duration, albeit not accounting for firm or term specificity of discount rates, earn a higher risk premium. Several recent papers have extended these results to show that a variety of other cross-sectional factors can be explained by this "duration premium", e.g. Chen and Li [22], Goncalves [34], and Gormsen and Lazarus [36]. I show in Appendix A.4 that my results are consistent with the findings of these papers because rebalanced portfolios in the cross-section have different dividend risk term structures, which means that the term structure can be upward-sloping for every firm while short duration firms still carry higher risk premia.

The claims of the existing derivative-based term structure literature, recently summarized in van Binsbergen and Koijen [57], are that the term structure of equity risk premia is either downward-sloping at short horizons, downward-sloping at some horizon, or has a downward-sloping term structure of Sharpe Ratios or volatility. As van Binsbergen and Koijen [57] discuss, any of these would be inconsistent with standard calibrations of an long run risks, rare disasters, or

and Martin [48] as I consider dividend growth forecasting variables, most notably aggregate market or sectoral dividend shares in consumption, used extensively therein and in subsequent research. I find that these variables are not necessary to increase the replication fit of the model I propose below, and their inclusion does not alter the qualitative conclusions of my results.

habit model in some respect. van Binsbergen, Brandt, and Koijen [55] report the claim that term structures slope downward at some horizon based on the prices of continuation and dividend claims implied by no-arbitrage assumptions and the prices of market equity options. They show that very short claims seem to have higher risk premia and volatility than the asset in their data. The claims of downward sloping returns and Sharpe Ratios are based on traded equity market dividend strip data presented in van Binsbergen, Hueskes, Koijen, and Vrugt [56] and extended in both van Binsbergen and Koijen [57] and Gormsen [35].

There remains considerable discussion on the implications of the dividend strip evidence; Bansal, Miller, Song, and Yaron [8] discuss issues associated with the span and liquidity of the data and show that its support for a downward sloping term structure is limited after accounting for the data limitations.[5] They show that extending the dataset to account for a longer history of dividend growth data may result in an upward sloping unconditional term structure - a point I am able to confirm by expanding the span and scope of the test assets. Callen and Lyle [19] document similar conditional evidence using firm-level option data, showing upward slopes in normal times and downward slopes in extreme recessions.

Another branch of the term structure literature examines the risk term structures of other, non-equity, asset classes to provide additional insight into the term structure of risk embedded in the pricing kernel, as opposed to the specific loading on priced risks embedded in equity. This paper focuses exclusively on the evidence related to equity risk term structures, so I refer the interested reader to the survey

[5] Boguth, Carlson, Fisher, and Simutin [18], Song [53], and Schulz [52] show why inference regarding dividend strips based on equity options is suspect due to, respectively, microstructure effects, dealer funding costs, and tax issues. Mixon and Onur [50], Klein [44], and Gomes and Ribeiro [32] raise similar issues of liquidity and price representativeness to Bansal, Miller, Song, and Yaron [8] in the dividend strip markets.

of this growing literature in van Binsbergen and Koijen [57].

A common theme in each of these branches of the empirical term structure literature is the attempt to increase the span and scope of the data that can speak directly to the risk term structure. I extend the literature by developing a method that expands both the span and scope of the data available to test the slope of the equity risk premium term structure. In the next section, I describe how the values of continuation claims, claims to the terminal value of the firm or its capital gains, can be used to test the term structure predictions of an asset pricing model and show how a price series for these claims can be obtained through replication and no-arbitrage.

1.2 Methods

In this section, I lay out a method for estimating a term structure of expected returns from firm returns and valuations (dividend to price ratios). The benefit of term structure data for testing asset pricing models lies in dividing the infinite horizon claim to firm dividends, a stock asset or firm claim, into a set of claims that are exposed to risks at different horizons. This division provides the researcher with a powerful set of moments with which to evaluate an asset pricing model. A typical approach using the term structure, e.g. van Binsbergen and Koijen [57] examines stripped coupon or dividend claims. I show that using claims to the continuation value of the firm at a given horizon, a claim to the firm price n periods ahead, P_{t+n}, at time t, contains the same pricing information. I then demonstrate how a straightforward replication experiment can be used to compute the prices of these claims.

1.2.1 Continuation and Dividend Strip Returns

First, I introduce notation and review the relationship between cash flow strip pricing and firm pricing. Denote the level of the firm dividend at time t, D_t, which is observed in the data. The price of the firm's stock at time t is P_t and its (gross) return from time t to time $t+1$ is $R_{t+1} = \frac{D_{t+1}+P_{t+1}}{P_t}$, both of which are also observed in the data. I will denote multi-period returns as $R_{t,t+n} = \prod_{h=1}^{n} R_{t+h}$. Call a security that pays D_{t+n} at time $t+n$ a dividend claim or dividend strip at horizon n and let it have price $\Pi^n_{d,t}$ at time t. Call a security that pays P_{t+n} at time $t+n$, a claim to the firm's continuation value or capital gains, a continuation claim at horizon n and let it have price $\Pi^n_{p,t}$ at time t. Then the return on a strip from time t to $t+1$ is $R^n_{d,t+1} = \frac{\Pi^{n-1}_{d,t+1}}{\Pi^n_{d,t}}$, or $R^1_{d,t+1} = \frac{D_{t+1}}{\Pi^1_{d,t}}$ for horizon one and the return on a continuation claim from time t to $t+1$ is $R^n_{p,t+1} = \frac{\Pi^{n-1}_{p,t+1}}{\Pi^n_{p,t}}$, or $R^1_{p,t+1} = \frac{P_{t+1}}{\Pi^1_{p,t}}$ for horizon one. I begin with the one period case for simplicity of exposition. Multi-period extensions are straightforward and appear in Appendix A.1.

Under the law of one price there exists a stochastic discount factor (SDF), M_{t+1}, denoted $M_{t,t+n}$ for the multi-period SDF. By definition a return is an asset with a price of one:

$$1 = E[M_{t+1}R_{t+1}] = \frac{\Pi^1_{d,t} + \Pi^1_{p,t}}{P_t} \tag{1.1}$$

The second equality follows from the law of one price, and shows that the asset consists of a portfolio of dividend and continuation claims. Thus the asset return can also be written as a portfolio of returns on the dividend and continuation claims:

$$R_{t+1} = \frac{\Pi^1_{d,t}}{P_t}\frac{D_{t+1}}{\Pi^1_{d,t}} + \frac{\Pi^1_{p,t}}{P_t}\frac{P_{t+1}}{\Pi^1_{p,t}} = \frac{\Pi^1_{d,t}}{P_t}R^1_{d,t+1} + \frac{\Pi^1_{p,t}}{P_t}R^1_{p,t+1} \tag{1.2}$$

The price and return of the asset are known, so if the price and return of the dividend claim are known, then the price of the continuation claim is also known and vice versa. A similar relationship holds for multiple horizons. This is the sense in which the continuation claim term structure and the dividend claim term structure contain the same pricing information. We can therefore use either term structure to test the predictions of an asset pricing model. The existing literature focuses on the dividend claim term structure, specifically on the term structure of dividend yields and expected returns, because derivative data exists for these assets from 2002 on, or for short horizons through option data from 1996 on. This literature uses mean realized returns or return expectations, exploiting the fact that the dividend strip yield can be decomposed into expected returns and dividend growth:

$$\frac{D_t}{P_t - \Pi_{p,t}^1} = \frac{D_t}{\Pi_{d,t}^1} = E_t\left[\frac{D_{t+1}/\Pi_{d,t}^1}{D_{t+1}/D_t}\right] = E_t\left[\frac{R_{d,t+1}^1}{D_{t+1}/D_t}\right] \tag{1.3}$$

The third and fourth terms show that conditional expected returns can be extracted from yields with an estimate of conditional growth expectations, which helps to explain the focus on yields in the existing literature. The first and second terms explain the relationship between this paper and previous work. The first continuation claim differs from the asset only by the first dividend claim, and a similar relationship holds for longer horizons: $\Pi_{d,t}^n = \Pi_{p,t}^{n-1} - \Pi_{p,t}^n$. For any horizon the next continuation claim only excludes the next dividend claim relative to the continuation claim at the previous horizon. I focus on the differences between continuation claims and the asset, while previous work examines the dividend claims, but the same pricing information is contained in both.

To discuss the full term structure, I shift to a multi-horizon approach. The most important relationship for what follows is the multi-period analogue of Equation (1.2), which shows that the stock return can be written as a portfolio of dividend and continuation claims at any horizon:

$$R_{t+1} = \frac{\Pi_{d,t}^1}{P_t} R_{d,t+1}^1 + \frac{\Pi_{d,t}^2}{P_t} R_{d,t+1}^2 + ... + \frac{\Pi_{d,t}^n}{P_t} R_{d,t+1}^n + \frac{\Pi_{p,t}^n}{P_t} R_{p,t+1}^n \tag{1.4}$$

Using this fact, I document two empirically useful relationships between dividend and continuation claim term structures in the following proposition:

Proposition 1.2.1. *Term Structure Relationships:*

1. *If the term structure of expected returns to dividend claims is everywhere monotonic then the term structure of expected returns to continuation claims is everywhere monotonic in the same direction:*

$$E_t[R^n_{d,t+1}] \geq (\leq) E_t[R^{n-1}_{d,t+1}] \;\; \forall \;\; n \quad \implies \quad E_t[R^n_{p,t+1}] \geq (\leq) E_t[R^{n-1}_{p,t+1}] \;\; \forall \;\; n$$

2. *The average dividend claim return for all horizons less than n is equal to the scaled difference of the asset return and the continuation claim return:*

$$\sum_{m=1}^{n} \frac{\Pi^m_{d,t}}{P_t - \Pi^n_{p,t}} R^m_{d,t+1} = \frac{1}{P_t - \Pi^n_{p,t}} (R_{t+1} - \Pi^n_{p,t} R^n_{p,t+1})$$

While I state these facts as a proposition for easy reference, they are both direct implications of Equation (1.4), so the proof is uninformative. The intuition for both is simple. The first fact is immediate from taking the conditional expectation of Equation (1.4). The continuation claim return is a weighted average of all subsequent dividend claim returns, thus when we move from horizon $n-1$ to n we remove only the horizon n dividend claim. This claim has a lower (higher) expected return than all subsequent claims when the strip term structure is monotone increasing (decreasing), thus removing it increases (decreases) the average. The second claim is even more straightforward and follows from the same manipulation - the continuation claim at horizon n and the dividend claims for horizons less than or equal to n are the same portfolio of claims as the stock. Rearranging Equation

(1.4) and multiplying by $P_t/(P_t - \Pi^n_{p,t})$ delivers the result.

These facts allow me to derive tests for whether distant claims have greater or lesser expected returns than near-term claims, tests that utilize only the prices of continuation claims[6]. The first fact is useful because of its contrapositive - if the term structure of continuation claims is not monotonic then the term structure of dividend claims is not everywhere monotonic. Thus, testing the slope of the continuation claim expected return term structure lets us falsify universal monotonicity of the strip term structure. The second fact suggests a direct test - since the continuation claim at horizon n contains only longer-term claims than the dividend claims up to n, testing the continuation claim return relative to the asset return directly evaluates whether the more distant continuation claim has a greater or lesser return than the nearer term dividend claims.

Finally, we can test the cumulative strip term structure directly using the second claim since the price of the cumulative claim up to n is always $P_t - \Pi^n_{p,t}$. This is empirically useful because dividend prices at long horizons are small, generally less than 4% of the asset price, and bounded below by zero, so even minuscule pricing errors in the two continuation claim prices used to compute $\Pi^n_{d,t} = \Pi^{n-1}_{p,t} - \Pi^n_{p,t}$ can result in noisy estimates of the dividend return that may come close to violating this boundedness. Comparing the price of one asset that is well estimated, the continuation claim, and one asset that is known, the return, alleviates the compounding of estimation error and results in less noisy estimates. This makes the use of cumulative dividend claims both an empirically desirable

[6]It is worth noting in conjunction with these facts that the slope of the risk premium term structure for dividend claims is related directly to the second derivative of the slope of the continuation term structure, i.e. the slope is determined by whether $\frac{\Pi^{n-2}_{p,t}}{\Pi^{n-2}_{p,t} - \Pi^{n-1}_{p,t}}(E_t[R^{n-2}_{p,t+1}] - E_t[R^{n-1}_{p,t+1}]) \leq (\geq) \frac{\Pi^n_{p,t}}{\Pi^{n-1}_{d,t} - \Pi^n_{p,t}}(E_t[R^{n-1}_{p,t+1}] - E_t[R^n_{p,t+1}])$. This is why the converse of the first fact is not necessarily true.

and theoretically valid method of investigating return term structures. In the next section I introduce a method for computing continuation claim prices using only stock return and valuation (dividend to price ratio) data and the assumption of no arbitrage that will allow me to exploit these two facts and test the slope of the term structure explicitly.

1.2.2 No-Arbitrage Prices of Continuation Claims

The core empirical challenge of conducting term structure inference is that the term structure of dividend claim prices is not observed at the firm level. Existing research relies on assumptions about relative firm risk or data on traded market derivatives. I introduce methods to extract implied firm continuation claim prices from the cross section via a replication exercise and the assumption of no-arbitrage. This allows me to use a dataset with substantially greater span and liquidity when analyzing market claims and also to directly estimate previously unavailable claim prices for portfolios in the cross-section.

The most important characteristic of the data that permits a replication exercise is that we know the price of assets accounting for almost all of the variation in the continuation value. We can rearrange the definition of the return as:

$$\frac{P_{t+1}}{P_t} = -\frac{D_t}{P_t} + R_{t+1} - \frac{\Delta D_{t+1}}{P_t} \tag{1.5}$$

Or for multiple periods:

$$\frac{P_{t+n}}{P_t} = -n\frac{D_t}{P_t} + R_{t,t+n} - \sum_{m=0}^{n-1}\left(R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-m}}\frac{D_{t+n-m}}{P_{t+n-1-m}} - \frac{D_t}{P_t}\right)$$

Which can be rewritten as:

$$\frac{P_{t+n}}{P_t} = -n\frac{D_t}{P_t} + R_{t,t+n} - \frac{D_t}{P_t}\sum_{m=0}^{n-1}\left(R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-1-m}}\frac{D_{t+n-m}/D_t}{P_{t+n-m}/P_t} - 1\right) \quad (1.6)$$

The final term of each equation is the only component with an unknown price.[7] The structure of Equation (1.6) leads me to construct the no-arbitrage prices of dividend and continuation claims using a simple replication exercise. The object of interest is the price of a claim to the per-share price of the stock n years in the future, P_{t+n}, denoted $\Pi^n_{p,t}$. The replication exercise is as follows. We desire to match the realized payoff of a continuation claim n periods in the future using realized cumulative returns, $R_{t,t+n}$, and conditioning on the firm's dividend to price ratio $\frac{D_t}{P_t}$. The essential characteristic of the replicating portfolio assets is that the price of a claim to their cash flows at $t+n$ is known at time t, so in principle additional conditioning time t variables or realized cumulative returns could be used. I find that such variables are empirically unnecessary to replicating continuation claim payoffs, and so tend towards the parsimony of the three factor model. We could write the replication exercise as:

$$\frac{P_{t+n}}{P_t} = b_0 + b_z\frac{D_t}{P_t} + b_r R_{t,t+n} + b_{zr}\frac{D_t}{P_t}R_{t,t+n} + \epsilon_{t,t+n} \quad (1.7)$$

If dividend to price ratios do not move much relative to the other elements, then a regression of capital gains on returns omits only the final term of the decomposition in Equation (1.6). At horizon 1 this piece is just the dividend growth scaled by

[7] I derive Equation (1.6) in detail in Appendix A.2.

the current price. As Equation (1.6) shows, at longer horizons this missing piece will be correlated with the interaction of cumulative returns and the dividend to price ratio. I decompose the covariance of the rebalanced CRSP market return into these components in Tables 1.1 and 1.2, which show that very little of the movement is driven by the dividend to price ratio or interaction terms. The contribution of the interaction terms increases somewhat with horizon but almost all the variation is driven by the capital gains term up to five years out. This suggests that a replication of capital gains with returns, dividend to price ratios, and their interaction would be highly accurate, a fact I confirm below.

Note that in Equation (1.7) the errors, $\epsilon_{t,t+n}$, are the basis risk of the replication. If we estimate the coefficients of the replicating portfolio using a regression, the realizations of the basis risk will equal the regression residuals in-sample. In order to proceed, I make two important economic assumptions here. The first is that there are no arbitrage opportunities in securities markets and that there would be no arbitrage opportunities in securities markets were liquid claims to firm dividends and continuation value to be traded in the market. Taking expectations under the risk-neutral measure prices Equation (1.7):

$$\frac{\Pi^n_{p,t}}{P_t} = E_t\left[M_{t,t+n}\frac{P_{t+n}}{P_t}\right] = b_0 E_t\left[M_{t,t+n}\right] + b_z E_t\left[M_{t,t+n}\frac{D_t}{P_t}\right] +$$

$$+ b_r E_t\left[M_{t,t+n}R_{t,t+n}\right] + b_{zr} E_t\left[M_{t,t+n}\frac{D_t}{P_t}R_{t,t+n}\right] + E_t\left[M_{t,t+n}\epsilon_{t,t+n}\right] \quad (1.8)$$

The right hand side of Equation (1.8) is straightforward to evaluate. The price of any instrument known at time t, the constant and the dividend to price ratio in this case, is simply the value of the instrument discounted at the riskfree rate. The

Table 1.1: Covariance of Return Decomposition Elements - Horizon One

	$R_{t,t+n}$	P_{t+n}/P_t	D_t/P_t	Interaction
$R_{t,t+n}$	1.000	0.962	0.022	-0.007
P_{t+n}/P_t	0.962	0.931	0.017	-0.011
D_t/P_t	0.022	0.017	0.004	0.004
Interaction	-0.007	-0.011	0.004	0.004

Notes: I present the covariance matrix of returns, capital gains, dividend to price ratios, and the scaled dividend growth term as described by Equation (1.5), scaled by the variance of the return. This is for the horizon 1 return only. The data is the CRSP rebalanced, value weighted market index from 6/1950 to 6/2012.

Table 1.2: Covariance of Return Decomposition Elements - Horizon Five

	$R_{t,t+n}$	P_{t+n}/P_t	D_t/P_t	Interaction
$R_{t,t+n}$	1.000	0.960	0.021	-0.008
P_{t+n}/P_t	0.960	0.927	0.015	-0.012
D_t/P_t	0.021	0.015	0.005	0.004
Interaction	-0.008	-0.012	0.004	0.005

Notes: I present the covariance matrix of returns, capital gains, dividend to price ratios, and the interaction term as described by Equation (1.5), scaled by the variance of the return. This is for the horizon 5 return only. The data is the CRSP rebalanced, value weighted market index from 6/1950 to 6/2012.

price of a cumulative return is one by definition. Substituting the known prices gives:

$$\frac{\Pi^n_{p,t}}{P_t} = \frac{b_0}{R^f_{t,t+n}} + \frac{b_z}{R^f_{t,t+n}}\frac{D_t}{P_t} + b_r + b_{zr}\frac{D_t}{P_t} + E_t\Big[M_{t,t+n}\epsilon_{t,t+n}\Big] \tag{1.9}$$

The second assumption that is necessary to obtain a price for the dividend and continuation claims is how to price the basis risk $E_t[M_{t,t+n}\epsilon_{t,t+n}]$. Note that by construction the basis risk is conditionally uncorrelated with the cumulative returns $R_{t,t+n}$. Thus there are two sufficient conditions that would lead to negligible basis risk, $E_t[M_{t,t+n}\epsilon_{t,t+n}] \approx 0$, either $R_{t,t+n}$ is the only priced risk relevant to the continuation claims at all horizons, or the variance of the basis risk is nearly zero $V_t(\epsilon^n_{t,t+n}) \approx 0$. The former assumption is both theoretically and empirically undesirable because it requires the researcher to know the true model that prices assets, converted to a factor model. I assume the latter condition, $V_t(\epsilon^n_{t,t+n}) \approx 0$, holds throughout and provide evidence supporting this from the regression outputs for Equation (1.7), since if $V_t(\epsilon^n_{t,t+n}) \approx 0$ the regression R-squared must be very close to one. Note that even if jumps are present in the true data generating process, they would have to be present in $R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-1-m}}\frac{D_{t+n-m}/D_t}{P_{t+n-m}/P_t}$ but not in $R_{t,t+n}$ and highly priced despite the difference between these two terms generating almost none of the variance of capital gains historically in order to violate my assumption.

I refer to the price estimate assuming the basis risk price is zero as $\hat{\Pi}^n_{p,t}$ when the distinction is relevant. Equation (1.9) and its one period ahead analogue for the same asset or portfolio give a time series of prices for each continuation claim relative to the asset, estimates of a time series of $\frac{\hat{\Pi}^n_{p,t}}{P_t}$ for each horizon for which the regression is run. From these we can construct a time series of realized annual holding period returns across the term structure by multiplying by the current firm price.

$$\hat{R}^n_{p,t+1} = \frac{\hat{\Pi}^{n-1}_{p,t+1}}{\hat{\Pi}^n_{p,t}} \tag{1.10}$$

The moments of Equation (1.10) provide a means to test the hypotheses laid out in Section 1.2.1. I address the specifics of data and testing using these moments in Section 1.3, but first I address the performance of this method in a theoretical environment.

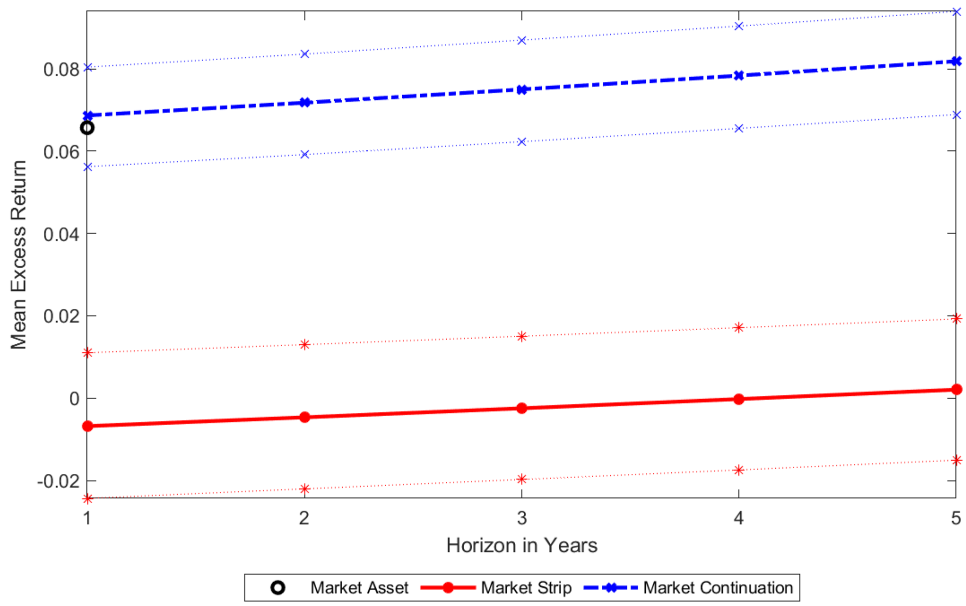
1.2.3 Validation of the Method

It remains to show that this method can reproduce the two necessary conditions for its validity - a high replication R-squared and the correct prices of continuation claims. I demonstrate the success of this method in a common affine theoretical environment with a vector of states evolving according to a stochastic volatility vector autoregression (SVVAR) and affine dividend betas and risk prices. This keeps the notation for the solution for strip expected returns and prices relatively compact while preserving the consumption-based general equilibrium model and allowing for some flexibility of parameterization. I present specifics of the model and the solution method in Appendix A.3 as it is entirely standard for this literature. I show that in this environment the regressions reproduce a high R-squared and the correct time series of prices.

The most important insight from the model solution is that any model of this general form generates different risk premia at different horizons solely through the different loadings of the strip pricing coefficients on the states at different horizons, which are driven entirely by difference in dividend betas and the relative persistence of the states. This is the core mechanism for generating cross-sectional differences in risk premia in work like Bansal, Dittmar, and Lundblad [5] and Hansen, Heaton, and Li [39]. Note that models like these also imply that when firms vary in dividend beta, their cash flow risk or strip premia will also differ at every horizon, not just on average for the asset. This means that cross-sectional differences in dividend beta rule out, in the general case, the single risk term structure assumption used as a theoretical tool to isolate the impact of duration in Lettau and Wachter [46], where only mean dividend growth rates differ across portfolios (and across time within firms).

A standard calibration of the model delivering a long run mean price to dividend ratio of 36.3, a long run mean asset risk premium of 6.54%, and asset return volatility of 15.2% gives the core predictions for the expected returns of both continuation and stripped claims as in Figure 1.1. The important predictions for the term structure, which I evaluate in the data, are that the continuation claim has an upward-sloping term structure that sits everywhere above the asset term structure. This is because long-duration claims hold higher risk premia than short duration claims across the term structure, so the basic shape of the continuation claim term structure follows immediately from Proposition 1.2.1. Cumulative dividend claim term structures approach the asset return from below. All of these relationships are displayed in Figure 1.1, which also gives the 25th and 75th percentile of the simulated mean excess returns. Note that the earliest strips will appear to be hedge assets in nearly half of realizations because their risk premium is so small. This is also likely to be the case in the data given

Figure 1.1: Expected 1 Period Risk Premia at the Unconditional Mean

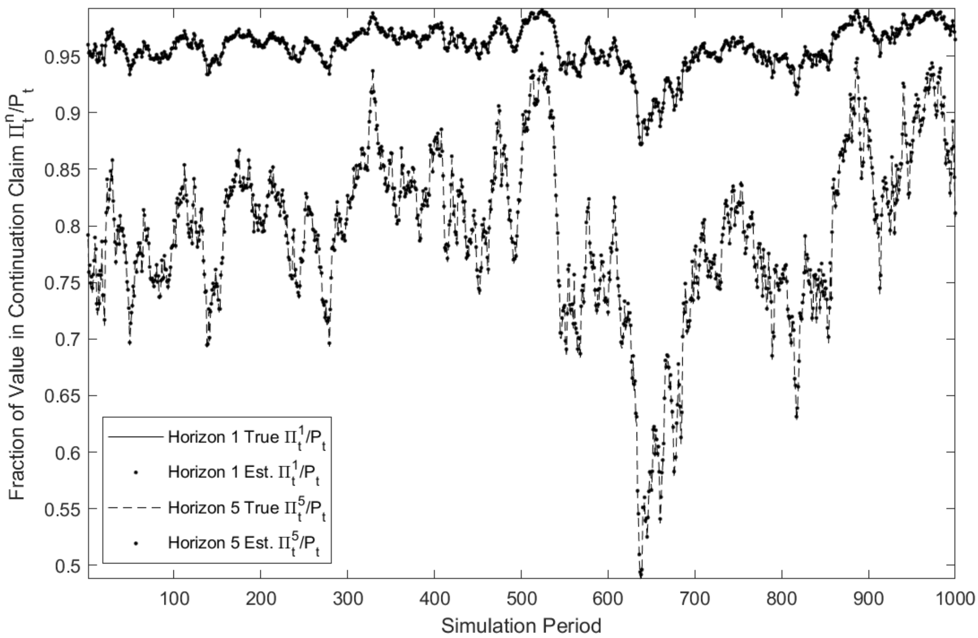


Notes: The grand mean risk premia of the asset, dividend claims, and continuation claims in the model. I simulate 1000 draws from a 60 year sample and record the grand mean and the simulated 25th and 75th percentile bands for the mean.

the minuscule contribution of short run realized growth shocks to asset returns displayed in Table 1.1, a fact which my results confirm.

The prices and expected returns of continuation claims are simple sums or means of the strip claim prices and returns as shown in Section 1.2.1. I simulate 1000 periods from the model and record the true prices of the dividend and consumption claims implied by the model. After this I run the regression proposed in Equation (1.7) and compute the no-arbitrage price of the continuation claims implied by applying Equation (1.9) using the model riskfree rate. I find an R-Squared of 0.99 or greater in both the replicating regression and for a regression of the model implied continuation claim prices on the estimated no-arbitrage prices from the replication experiment. Figure 1.2 presents a sample simulation run for two horizons, showing

Figure 1.2: True Model Prices of Continuation Claims Versus No-Arbitrage Estimates



Notes: The model generated true fraction of firm value in the continuation claim and the estimate of the fraction of firm value in the continuation claim implied by applying Equation (1.9) using the model riskfree rate for horizons one and five. I present a 1000 year sample run.

the continuation claim price as a line and the estimated claim prices as points. It is visually evident, confirming the high R-squared, that the price estimates track the true prices almost exactly. This confirms that the procedure indeed reproduces the correct price series when the replicating regression produces a high R-squared in a theoretical environment. I proceed to implement this procedure using the cross-section of U.S. stock returns.

1.3 Data and Implementation

Wherever possible I use standard, publicly available data sources. My primary source of return data is the Center for Research in Security Prices monthly stock file, Update [54], and the associated value weighted market return index for all US exchanges. I use the Compustat Industrial file, Compustat [24] for fundamental data including book equity, earnings, assets, and gross profitability data used in the formation of buy and hold portfolios in the cross section. I use the zero coupon nominal interest rate curve computed by Gürkaynak, Sack, and Wright [37] throughout. I extend this data slightly using US Treasury data, however sufficient zero coupon rates to conduct this analysis do not exist prior to about 1950. The riskfree rate is an essential component of the no-arbitrage prices of dividend claims and real riskfree series do not exist for the majority of my sample, so I conduct the replication and pricing analysis in nominal terms. Finally, I use the rebalanced cross-sectional return data constructed by Fama and French [28] directly whenever possible to provide easy comparison to earlier work. I also consider international returns as reported by the Thomson-Reuters Datastream indices.

Since I focus on firm outcomes, I use buy-and-hold portfolios for the cross-section for my primary results and present rebalanced portfolio evidence for completeness. I use the rebalanced market returns from CRSP as the market return for comparability with previous work, but the results for the buy-and-hold market are similar. A buy-and-hold portfolio, in contrast to a rebalanced portfolio, consists of the same set of firms throughout its life, up to the exclusion of exiting firms. Thus, it tracks firm performance without including rebalancing or entry effects. At each date τ from 6/1950 to 6/2012, I sort all firms on a characteristic, for example the ratio of book equity to market equity, and form decile portfolios. I refer to the formation date of a portfolio as its vintage. The buy-and hold portfolio for a given decile for a given vintage τ consists of all firms that were in that decile at date τ, regardless of future changes in characteristics. For decile portfolios, I exclude all firms with negative book value or that are missing the sort characteristic data in Compustat. The market portfolio for vintage τ consists of all firms in CRSP at date τ.

I construct capital gains and total return series for the market and the cross section of assets for monthly formed buy-and-hold portfolios, where accounting data is the most recent update as of six months prior. Using annual formation dates produces similar point estimates but noisier replication coefficients, even after accounting for the induced persistence of the data. I use standard rebalanced and buy and hold portfolio construction methods, as in Fama and French [28]. I extract three series for each cross sectional portfolio and for the market: the total return series, a capital appreciation series, and a total market capitalization series, all at a monthly frequency. For simplicity and consistency, I construct all variables using the methods of Bansal, Dittmar, and Lundblad [5]. The per share return of any security is:

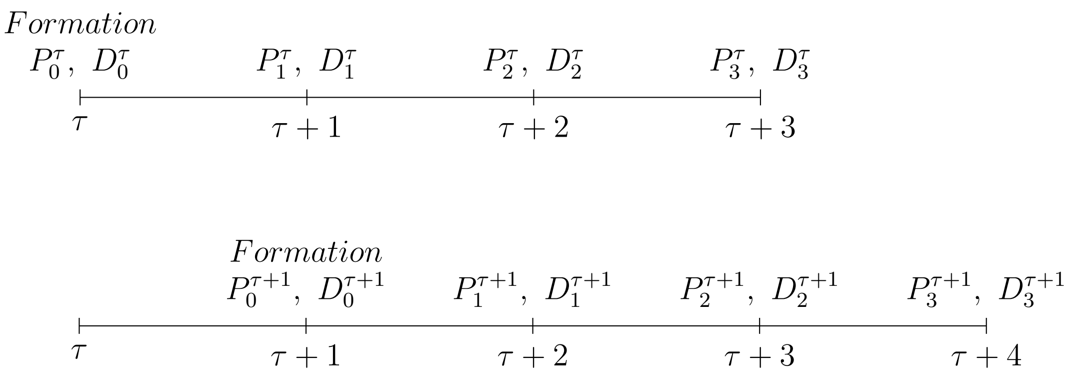
$$R_{t+1} = H_{t+1} + Y_{t+1} \tag{1.11}$$

Where $H_{t+1} = \frac{P_{t+1}}{P_t}$ is the per share capital gain and Y_{t+1} is the realized forward cash flow yield $\frac{D_{t+1}}{P_t}$. Given the total return and price per share capital gain series, I calculate the time series of Y_{t+1} for each portfolio at the monthly frequency. I also calculate a per share price series as the running product of H_{t+1}. I estimate the dividends paid per share for each month t+1 as the product of this price series at time t and the dividend yield variable Y_{t+1}. I estimate the aggregate dividends paid in month t+1 by multiplying Y_{t+1} by the total market capitalization variable for time t. I convert all dividend variables to the annual frequency by summing the relevant dividend series over the past 12 months. I use the per share price and dividends paid series at the annual frequency to construct the price to dividend ratio series as price divided by last 12 months dividends paid per share.

The resulting dataset consists of 11 portfolios (the market and each decile) formed at each vintage τ from 1950 to 2012. I track the outcomes of each portfolio for up to six years after formation. This gives a time series of six years of price appreciation, total return, per share dividends, and aggregate dividends for each portfolio for each vintage, forming a vintage-panel dataset. This vintage-panel dataset forms the basis of the replication exercise that allows me to estimate prices of claims to firm dividends and continuation value. I use the same vintage panel data construction process for the rebalanced portfolios, including the market, the only difference being that the return on a vintage τ rebalanced portfolio n periods ahead is just the rebalanced portfolio return at $\tau + n$, rather than the return on a buy-and-hold portfolio formed at a different date.

In implementing these regressions the continuation yields, or capital gains, $\frac{P_{\tau+n}}{P_\tau}$ are for realizations on a specific vintage τ portfolio. I then estimate the regression using a sample over vintage years for the same portfolio decile or the market for each horizon n between one and five years. I also need the one period ahead prices for the same assets to compute the numerator of Equation (1.10), $\hat{\Pi}^{n-1}_{p,t+1}$, and therefore run a second set of regressions, the one period ahead analogue of Equation (1.7). The only difference between these regressions are that all variables have been moved one period forward in time and that the regression is run at time $\tau + 1$ for a vintage τ portfolio, rather than at time τ for a vintage τ portfolio.

Figure 1.3: Vintage Portfolio Formation Timeline



Notes: The upper timeline presents the data formation for the vintage τ portfolio, the lower timeline for the vintage $\tau + 1$ portfolio. To emphasize the difference between this vintage data and time series data, I denote the vintage formation date as a superscript and the time since formation as a subscript, thus P_0^τ is the price at formation of the vintage τ portfolio, P_1^τ is the price 1 month later, and so on.

To make clear how the data is formed, I show a timeline of the data constructed as Figure 1.3. The upper timeline shows how prices and dividends are produced for the vintage τ portfolio, while the lower timeline does the same for the vintage $\tau + 1$ portfolio. To emphasize the difference between this vintage data and time series data, I denote the vintage formation date as a superscript and the time since formation as a subscript, thus P_0^τ is the price at formation of the vintage τ portfolio, P_1^τ is the price one month later, and so on.

The underlying assumption behind this sample formation is that the vintages represent a sample from a process with stationary risk and growth prospects. In unconditional expectation the portfolios formed at the various vintages must have the same risk and growth, an assumption that is ubiquitous in the literature for cross-sectional portfolios (my test assets) but questionable for individual firms. This is why I conduct the analysis at the portfolio rather than the firm level.

The sample of prices at horizon one is therefore $\{P_1^\tau, P_1^{\tau+1}, ..., P_1^T\}$, so varying across formation vintage produces the sample. Therefore I implement Equation (1.7) by regressing $\frac{P_1^\tau}{P_0^\tau}$ on $\frac{D_0^\tau}{P_0^\tau}$, R_1^τ, and $\frac{D_0^\tau}{P_0^\tau} R_1^\tau$, and so on, sampling across formation vintages τ:

$$\frac{P_n^\tau}{P_0^\tau} = b_0 + b_z \frac{D_0^\tau}{P_0^\tau} + b_r R_n^\tau + b_{zr} \frac{D_0^\tau}{P_0^\tau} R_n^\tau + \epsilon_n^\tau$$

This procedure produces a time series of prices for the continuation claims at all horizons for which the regression is run, both at the formation vintage and one year later. I use these price series to compute annual holding period returns for the continuation claim starting at each vintage formation date. This gives an overlapping vintage time series of realized holding period returns, for which I compute the mean excess return to provide my main results. In implementing the regressions I estimate both the replication coefficients and the mean returns as simultaneous equations using GMM with HAC standard errors to account for first stage estimation error in computing the mean return test statistics, as well as the induced persistence of the data. I will drop the subscripting by τ in what follows for brevity, assuming that sampling over formation vintages is understood.

1.4 Results

In this section, I document my main results. I begin by reporting the quality of the replication and forecasting experiments then present summary statistics for the resulting distributions of firm value and annual holding period returns.

1.4.1 Replication of Capital Gains

The first empirical issue is the quality of the replication. I use the book-to-market sorted cross section in my main results and produce supporting results for other cross-sectional sorts in Appendix A.5. I also consider additional predictive variables used extensively in the literature: valuations of the cross-section, aggregate dividend shares in consumption of the cross-section, and riskfree rates, finding that the parsimonious model with only the own-portfolio valuation and return is sufficient to deliver very high replication quality and additional variables do not qualitatively alter the results[8].

I report the results for the replication regressions in Tables 1.3 and 1.4. Note that because both stages, the replication and mean return estimation, of the estimation are linear the GMM point estimates are the OLS estimates but the standard errors are larger depending on the first stage estimation error. As shown in Table 1.3, I find that the replications are highly precise for the continuation claims throughout the cross-section and for the market, generating R^2's greater than .99 for nearly all test portfolios and horizons[9]. Much of this high replication quality is driven

[8] Valuations in the cross-section and riskfree rates are standard in the consumption-based asset pricing literature. Aggregate shares are discussed and examined as predictive variables in Menzly, Santos, and Veronesi [49], Lettau and Ludvigson [45], and Martin [48].

[9] The high quality of the replication is not limited to the continuation claim portion of the asset. The cumulative reinvested dividends are implicitly approximated by $R_n^\tau - \hat{P}_n^\tau / P_0^\tau$, where the latter term is the quantity being replicated directly in the regression. The pseudo-R^2 of

by the fact that I am regressing cumulative capital gains on cumulative returns. Comparing Equation (1.6) with the estimated price reinforces why this works so well:

$$\frac{P_n}{P_0} = 0 - n\frac{D_0}{P_0} + R_n - \frac{D_0}{P_0}\sum_{m=0}^{n-1}\left(R_{n-1-m}\frac{P_n}{P_{n-1-m}}\frac{D_{n-m}/D_0}{P_{n-m}/P_0} - 1\right)$$

$$\frac{P_n}{P_0} = b_0 + b_z\frac{D_0}{P_0} + b_r R_n + b_{zr}\frac{D_0}{P_0}R_n + \epsilon_n$$

The former equation is the true relationship while the latter is the approximation. Capital gains and returns differ only by the accumulated dividend payments, and the interaction term picks up some of this at longer horizons. Note that if we executed the true relationship exactly, $b_r = 1$ and $b_z = -1$. Including the interaction terms pushes the b_r coefficient towards its true value relative to a regression of capital gains on returns alone, where b_r is lower and more distant from one. The interaction term combined with the persistence of dividend to price ratios allows for predictability in the missing dividend piece since $\frac{D_n/D_0}{P_{n-1}/P_0}$ is small up to horizon five and does not appear to cause large jumps that are missed by the replication. Table 1.5 shows that the same relationships are borne out in the buy-and-hold cross-section.

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the implied dividend regression is therefore $1 - \frac{\sum_{\tau=1}^{T}(\hat{P}_n^\tau/P_0^\tau - P_n^\tau/P_0^\tau)^2}{\sum_{\tau=1}^{T}(R_n^\tau - P_n^\tau/P_0^\tau - T^{-1}[\sum_{\tau=1}^{T}(R_n^\tau - P_n^\tau/P_0^\tau])^2}$. This quantity ranges from 95.9% at horizon 1 for the market to 94.4% at horizon 3 and 94.1% at horizon 5, displaying excellent fit for the cumulative dividends as well. Increasing the number of instruments or returns in the regression as described above and in the previous footnote only marginally increases the implied dividend fit and does not materially alter the results.

Table 1.3: R^2 and RMSE of Capital Gains Replication

Claim	Market R^2	Market RMSE	Growth (BM 2) R^2	Core (BM 5) R^2	Value (BM 9) R^2
P_1/P_0	99.9+%	0.3%	99.9+%	99.9%	99.9%
P_3/P_0	99.7%	1.4%	99.8%	99.6%	99.5%
P_5/P_0	99.5%	3.5%	99.7%	99.2%	99.0%

Notes: I present the regression R-squared and root-mean-squared-error for the replication regression $\frac{P_n}{P_0} = \frac{P_n}{P_0} = b_0 + b_z\frac{D_0}{P_0} + b_r R_n + b_{zr}\frac{D_0}{P_0}R_n + \epsilon_n$. I use monthly formation dates from 6/1950 to 6/2012 form the vintage-panel dataset used to estimate the regression. For brevity I present the results for the continuation claims at horizons 1, 3, and 5, for the market and portfolios 2, 5, and 9 in the Book-to-Market sorted cross-section.

Table 1.4: Capital Gains Replication Regression Coefficients - Market

	P_1/P_0	t-stat	P_3/P_0	t-stat	P_5/P_0	t-stat
b_0	0.005	[1.956]	0.011	[0.928]	0.025	[0.922]
b_z	-0.774	[-6.059]	-2.054	[-3.581]	-4.162	[-3.138]
b_r	0.994	[550.620]	0.986	[126.650]	0.976	[56.455]
b_{zr}	-0.275	[-3.370]	-1.168	[-4.450]	-1.775	[-3.600]
R^2	1.000		0.997		0.995	

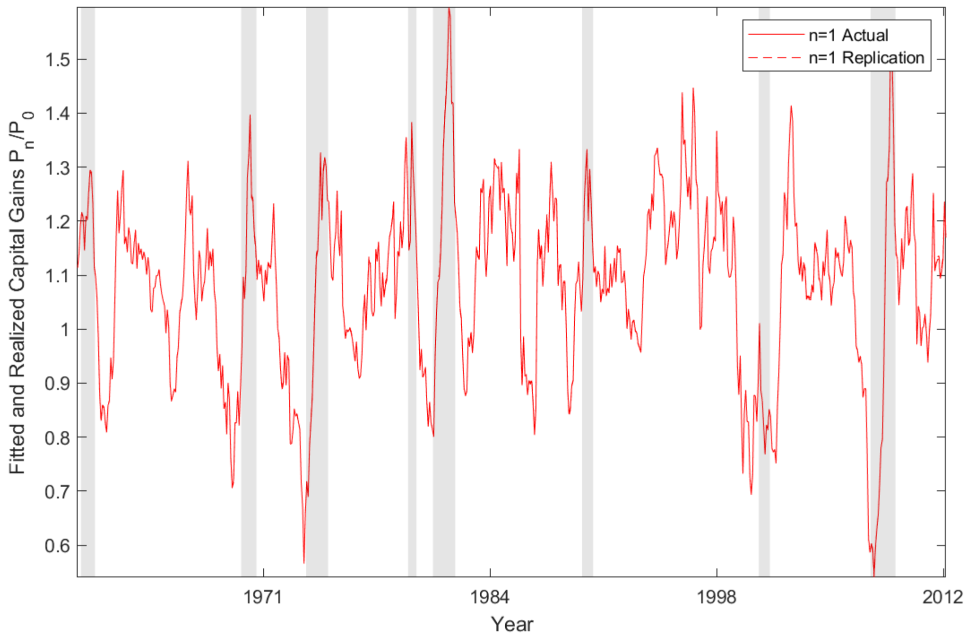
Notes: I present the coefficient estimates with t-statistics based on HAC standard errors for the replication regression $\frac{P_n}{P_0} = b_0 + b_z\frac{D_0}{P_0} + b_r R_n + b_{zr}\frac{D_0}{P_0}R_n + \epsilon_n$. I use monthly formation dates from 6/1950 to 6/2012 form the vintage-panel dataset used to estimate the regression. For brevity I present the results for the continuation claims at horizons 1, 3, and 5.

Table 1.5: Capital Gains Replication Regression Coefficients - Book to Market

	P_1/P_0	t-stat	P_3/P_0	t-stat	P_5/P_0	t-stat
			Portfolio 2 (Growth)			
b_0	0.001	[0.285]	-0.001	[-0.225]	0.020	[1.397]
b_z	-0.578	[-3.811]	-1.394	[-4.259]	-3.728	[-4.188]
b_r	0.996	[494.960]	0.988	[180.070]	0.961	[75.642]
b_{zr}	-0.373	[-3.241]	-1.413	[-9.464]	-1.531	[-4.102]
R^2	1.000		0.998		0.997	
			Portfolio 5 (Core)			
b_0	0.005	[1.759]	-0.002	[-0.128]	-0.017	[-0.577]
b_z	-0.717	[-8.507]	-1.267	[-3.108]	-2.085	[-1.962]
b_r	0.994	[548.880]	0.991	[170.440]	0.991	[87.780]
b_{zr}	-0.305	[-6.607]	-1.587	[-9.819]	-2.658	[-7.624]
R^2	0.999		0.996		0.992	
			Portfolio 9 (Value)			
b_0	0.007	[1.924]	0.023	[1.267]	0.013	[0.264]
b_z	-0.781	[-7.195]	-1.921	[-3.950]	-2.425	[-1.951]
b_r	0.992	[400.910]	0.967	[74.696]	0.955	[32.624]
b_{zr}	-0.205	[-2.815]	-0.924	[-4.021]	-1.851	[-3.560]
R^2	0.999		0.995		0.990	

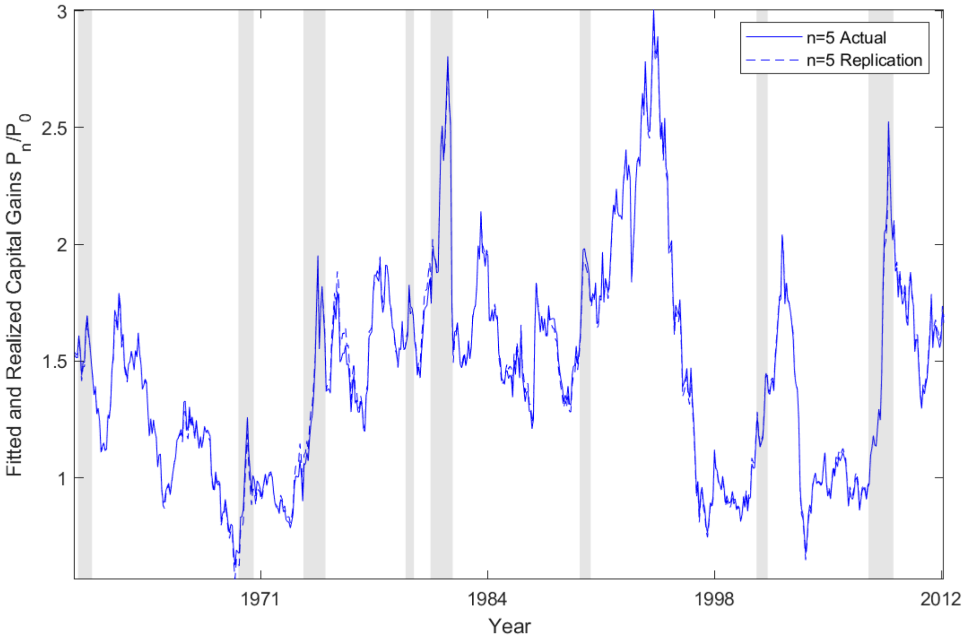
Notes: I present the coefficient estimates with t-statistics based on HAC standard errors for the replication regression $\frac{P_n}{P_0} = b_0 + b_z \frac{D_0}{P_0} + b_r R_n + b_{zr} \frac{D_0}{P_0} R_n + \epsilon_n$. I use monthly formation dates from 6/1950 to 6/2012 form the vintage-panel dataset used to estimate the regression. For brevity I present the results for the continuation claims at horizons 1, 3, and 5, for portfolios 2, 5, and 9 in the Book-to-Market sorted cross-section.

Figure 1.4: Continuation Claim Replication - Market Horizon 1



Notes: I present the replicated capital gains given by $b_0 + b_z\frac{D_0}{P_0} + b_r R_n + b_{zr}\frac{D_0}{P_0}R_n$ as a dashed line alongside the realized capital gains given by $\frac{P_n}{P_0}$ as a solid line for horizons one and five. I use monthly formation dates from 6/1950 to 6/2012 to compute the regression coefficients, and present the results for the rebalanced market.

Figure 1.5: Continuation Claim Replication - Market Horizon 5



Notes: I present the replicated capital gains given by $b_0 + b_z \frac{D_0}{P_0} + b_r R_n + b_{zr} \frac{D_0}{P_0} R_n$ as a dashed line alongside the realized capital gains given by $\frac{P_n}{P_0}$ as a solid line for horizons one and five. I use monthly formation dates from 6/1950 to 6/2012 to compute the regression coefficients, and present the results for the rebalanced market.

1.4.2 Non-Parametric Bounds on Error Pricing

While the replication results confirm that the assumption $E_t[M_{t,t+n}\epsilon_{t,t+n}] \approx 0$ holds in the data, it may still be the case that these errors carry a large risk premium due to a high correlation with a volatile SDF. One way to approach this issue is to approximate the maximal risk premium impact of the pricing errors for a SDF that is sufficiently volatile to price the test assets, following Hansen and Jagannathan [40][10]. Hansen and Jagannathan [40] provide the following condition for a SDF which is sufficiently volatile to price a set of test assets, indexed by i:

$$\sigma_{M_{t,t+n}} \geq E_t[M_{t,t+n}] \max \left\{ \frac{E_t[R_{t,t+n}] - R^n_{f,t}}{\sigma_{R_{t,t+n}}} \right\} \equiv \sigma^{HJ}_{M,t} \tag{1.12}$$

Where I denote the volatility of an SDF exactly achieving this bound $\sigma^{HJ}_{M,t}$. Since the errors are mean zero by construction, we can write the price of the errors as:

$$E_t[M_{t,t+n}\epsilon_{t,t+n}] = E_t[M_{t,t+n}]E_t[\epsilon_{t,t+n}] + COV_t[M_{t,t+n}\epsilon_{t,t+n}] = COV_t[M_{t,t+n}\epsilon_{t,t+n}]$$

For an SDF which is just volatile enough to price the test assets, i.e. which achieves the bound in Hansen and Jagannathan [40], we can write this as:

$$E_t[M_{t,t+n}\epsilon_{t,t+n}] = \rho_{M_{t,t+n},\epsilon_{t,t+n}}\sigma_{\epsilon_{t,t+n}}\sigma^{HJ}_{M,t} \tag{1.13}$$

[10] Numerous other forms of nonparametric bounds have been proposed in the literature, including growth-optimal bounds as in Bansal and Lehmann [7] and entropy bounds as in Backus, Chernov, and Zin [4].

The maximum risk premium impact of these errors occurs when $\rho_{M_{t,t+n},\epsilon_{t,t+n}} \in \{-1, 1\}$. Specifically, the concern may be that the errors increase the price of the continuation claims, driving down their risk premia, so I compute the unconditional mean price of the maximally valued errors in the data, i.e. when $\rho_{M_{t,t+n},\epsilon_{t,t+n}} = 1$ so that the errors are a hedge asset. Note that the price of these errors is a fraction of the asset price by construction, so I define the price of the unscaled errors as $\bar{\Pi}^n_\epsilon$:

$$\frac{\bar{\Pi}^n_\epsilon}{P_t} \equiv \sigma_{\epsilon_{t,t+n}} \sigma^{HJ}_{M,t} \geq E[M_{t,t+n}\epsilon_{t,t+n}] \tag{1.14}$$

I use the market portfolio as a representative asset in computing the volatility of the SDF.[11] I compute the fractional change in price resulting from these assumptions $\frac{\bar{\Pi}^n_\epsilon}{E[\Pi^n_t]}$ and present the results in Table 1.6.

The results in Table 1.6 show that for virtually all horizons, even in the case where the errors are perfectly correlated with the SDF, the impact of errors of this magnitude in the regression is small. Note that this is an upper bound, not a mean estimate, and that the true return impact of error pricing is unlikely to achieve or even approach this bound. The errors likely have a smaller correlation with the true SDF because they are uncorrelated with both the cumulative asset return and the asset return interacted with the dividend to price ratio by construction, both of which carry large risk premia and are therefore highly correlated with the true

[11] If I include all test assets, both cumulative dividend and continuation claims, for all portfolios in the book-to-market sorted cross-section in computing the maximum the values are increased by approximately 1.6 times. Adding the Sharpe Ratio of the duration-sorted cross-section from Weber [59] to the maximization approximately doubles the results. As this factor is recently discovered it is unclear whether a Sharpe Ratio of this magnitude is achievable out of sample after accounting for parameter uncertainty, so this likely provides an overestimate of the pricing bound for achievable returns. Regardless, the impact of the errors remains negligible even under more aggressive assumptions, especially at shorter horizons.

Table 1.6: Maximum Price Impact of Capital Gains Replication Errors

Horizon n	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$
Market	0.001	0.004	0.008	0.013	0.019
Growth	0.001	0.005	0.010	0.015	0.022
Core	0.001	0.005	0.010	0.016	0.023
Value	0.002	0.007	0.015	0.025	0.035

Notes: I present the upper bound for the impact of the pricing errors in $\frac{P_n}{P_0} = \frac{P_n}{P_0} = b_0 + b_z \frac{D_0}{P_0} + b_r R_n + b_{zr} \frac{D_0}{P_0} R_n + \epsilon_n$ as a fraction of the continuation claim value, $\frac{\bar{\Pi}^n_\epsilon}{E[\Pi^n_t]}$, using $\bar{\Pi}^n_\epsilon = \sigma_{\epsilon_{t,t+n}} \sigma^{HJ}_{M,t}$. I report This is the upper bound assuming the regression errors are perfectly correlated with the SDF for the SDF achieving the Hansen-Jagannathan bound.

SDF themselves. Both the small magnitude of the maximal pricing impact and the unlikelihood of achieving the maximum suggest that the true pricing errors have very little impact on the mean return estimates presented in the following sections.

1.4.3 Term Structures of Risk Premia

In this section I use the time series of the estimated prices of continuation claims $\hat{\Pi}^n_{p,t}$ along with Equation (1.10) to create a time series of realized annual holding period returns. First, I report the mean fraction of firm value in each continuation claim, $\frac{\hat{\Pi}^n_{p,0}}{P_0}$, generated by the regression outputs in Table 1.7. The statistics presented are the mean over the vintages produced by applying the pricing equation Equation (1.9) to the replication regression outputs. I find that, consistent with intuition and the literature, value assets deliver a greater fraction of their firm value in the near term and the reverse is true of growth assets, although these differences are not statistically significant in the cross-section. One reason these firms have such close durations is that the high discount rate firms in Portfolio 9 (Value) also have relatively high near-term dividend growth rates, which compresses the relative durations towards each other in the cross-section[12]. This is not something that can be accounted for without firm and term specific discount rates, and demonstrates the possibility of the existence of firms with high returns and low durations.

I present the mean excess returns for the assets and continuation and cumulative dividend claims by horizon in Table 1.8. I test two hypotheses about the data, first whether the continuation or cumulative dividend claim mean return exceeds the asset mean return and second whether the continuation claim return for horizons greater than one exceeds the horizon one continuation claim return. I present the results for the rebalanced market and for buy-and-hold portfolios for the cross-section, which are my main results as they represent a consistent set of firms and

[12]See Chen [21] for confirmation of this factual claim about relative returns and growth rates in buy-and-hold portfolios.

Table 1.7: Distribution of Value in the Book-to-Market Cross Section

Portfolio	$\hat{\Pi}^1_{p,0}/P_0$	$\hat{\Pi}^2_{p,0}/P_0$	$\hat{\Pi}^3_{p,0}/P_0$	$\hat{\Pi}^4_{p,0}/P_0$	$\hat{\Pi}^5_{p,0}/P_0$
Market	96.74%	93.52%	90.31%	87.13%	83.90%
Portfolio 1	97.39%	94.76%	92.15%	89.52%	86.65%
Portfolio 5	96.46%	92.97%	89.69%	86.38%	83.11%
Portfolio 9	96.04%	92.26%	88.65%	85.21%	81.96%

Notes: I present the mean over vintages of $\hat{\Pi}^n_{p,0}/P_0 = \frac{b_0}{R^n_{f,0}} + \frac{b_z}{R^n_{f,0}}\frac{D_0}{P_0} + b_r + b_{zr}\frac{D_0}{P_0}$ for several horizons in the cross-section. I use monthly formation dates from 6/1950 to 6/2012 form the vintage-panel dataset used to estimate the regression. For brevity I present the results for the market and portfolios 2, 5, and 9 in the Book-to-Market sorted cross-section.

therefore give a better indication of within-firm variation in discount rates.

There are several aspects of this output that bear emphasis. First, all of the point estimates of excess returns for the continuation claims of each asset are above the point estimates of the asset return, and for almost all test assets this difference is statistically significant at the 1% level for all horizons greater than 1. The lack of significance at horizon 1 is unsurprising given that the asset claim and the first continuation claim differ by only one dividend claim representing less than 4% of the asset's value on average. The reason the differences between the asset return and the continuation claim returns, and the differences among the continuation claim returns, are statistically significant is because the estimates are, as would be expected, highly correlated and the first stage estimation error is small. Similarly, the cumulative dividend claim returns are below the asset return and statistically significantly different from the asset return at the 1% level at all horizons. Second, all of the term structures of continuation claim returns slope upwards, with the difference between the horizon n return and the horizon 1 return being positive and significant at the 1% level for all horizons. The same is true of the cumulative

Table 1.8: Continuation Claim Excess Returns - Rebalanced Market

	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	6.61%	6.82%	7.13%	7.45%	7.88%	8.56%
Market SE	[1.05]	[1.50]	[1.62]	[1.72]	[1.83]	[1.95]
Model $E[R^n_{p,1} - R^1_{f,0}]$	6.54%	6.85%	7.18%	7.51%	7.85%	8.21%
Model 25th Percentile	2.98%	3.22%	3.54%	3.86%	4.19%	4.52%
Model 75th Percentile	9.58%	9.95%	10.31%	10.69%	11.03%	11.40%

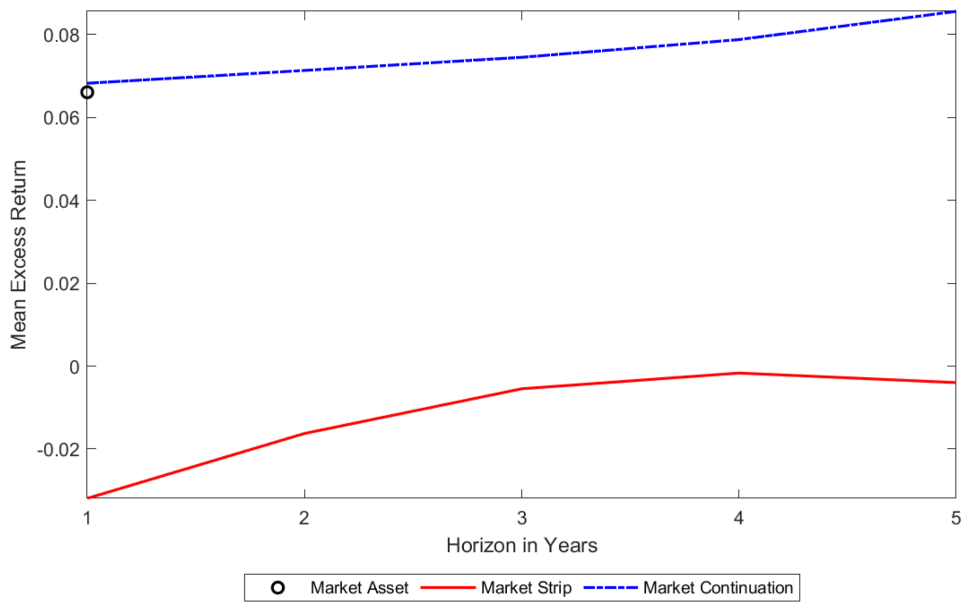
Notes: I present results for the CRSP rebalanced market of the mean excess returns of the asset and the estimated excess returns of the continuation claim. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the rebalanced market. I also present the comparable statistics and 25th and 75th percentile bands for the model described in Section 1.2.3.

Table 1.9: Cumulative Dividend Claim Excess Returns - Rebalanced Market

	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	6.61%	-3.19%	-1.63%	-0.55%	-0.17%	-0.40%
Market SE	[1.05]	[2.30]	[2.55]	[2.40]	[2.11]	[1.77]
Model $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	6.54%	-1.09%	-0.84%	-0.58%	-0.32%	-0.06%
Model 25th Percentile	2.98%	-5.90%	-5.59%	-5.38%	-5.11%	-4.83%
Model 75th Percentile	9.58%	3.72%	3.96%	4.18%	4.41%	4.67%

Notes: I present results for the CRSP rebalanced market of the mean excess returns of the asset and the estimated excess returns of the cumulative dividend claims. The dividend claim returns are given by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the rebalanced market. I also present the comparable statistics and 25th and 75th percentile bands for the model described in Section 1.2.3.

Figure 1.6: Term Structures of Risk Premia - Rebalanced Market



Notes: I present results for the CRSP rebalanced market of the mean excess returns of the asset and the estimated excess returns of the continuation claim and cumulative dividend claim. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the cumulative dividend claim returns by $\hat{\hat{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the rebalanced market.

dividend claims at the point estimates, although greater estimation noise and less correlated returns result in lower statistical significance. I present the equivalent of Table 1.8 for a variety of other cross-sections in Appendix A.5 and the conclusions are qualitatively the same the market results and generally statistically significant. The construction of these alternative sorts follows that of Fama and French [28].

The implications for the relative risk of long duration or distant claims and short duration claims are stark: longer duration claims have higher excess returns across test assets and horizons, and most of these relationships are statistically significant. Recall from part two of Proposition 1.2.1 that the asset is a shorter duration claim than any of the subsequent continuation claims. My results imply that for all test assets and horizons the value-weighted average dividend claim with a horizon less than five is less risky than the asset, and also that the dividend claim at each horizon is less risky than the continuation claim at the same horizon. This is simply because the portfolio of claims representing the asset differs from the portfolio representing the continuation claim by only the intervening dividend payments as in Equation (1.2). Note that this is the opposite finding from that of van Binsbergen, Hueskes, Koijen, and Vrugt [56], who show that option-implied dividend claims are riskier than the asset in their sample.

My results also show that the continuation or cumulative dividend claims at each horizon have a higher excess return than the continuation or cumulative dividend claims at lower horizons. Since the continuation claim is a longer duration asset at longer horizons because it merely strips off more early dividend payments, this shows an upward slope to risk premia for continuation claims as well. Based on part 1 of Proposition 1.2.1 I can also reject the hypothesis of a universally downward sloping dividend strip risk premium curve on this basis. The cumulative strip evidence directly supports an upward-sloping strip risk premium curve. This evidence also seems to conflict with the derivatives-based return data of van Binsbergen and Koijen [57], who find a downward or insignificant slope to dividend claims excess returns. In the following section, I show indicative evidence based on the recent subsample that both this difference in conclusions and the difference with van Binsbergen, Hueskes, Koijen, and Vrugt [56] may be due to unique characteristics of the subsample for which those authors' data is available.[13]

[13]Note that van Binsbergen and Koijen [57] also claim that the Sharpe Ratios of these returns are inconsistent with the predictions of major macro-finance models. I show in Table A.8 in Appendix A.5 that the Sharpe Ratios of both continuation and cumulative dividend claims are consistent with the predictions of the standard macro-finance model presented in Section 1.2.3.

For the cumulative dividend claims my evidence now seems to present the opposite puzzle: the early strip excess returns are negative, implying that near term dividends are actually a hedge asset. This at first seems counterintuitive, however two facts lend credibility to the result. First, a standard affine model produces near-zero risk premia for early dividend claims, as I showed in Section 1.2.3. Second, even in a sample of 60 years the standard error bands on the mean for the strips are relatively large. The point estimate for the mean cumulative strip returns in the data is well within the 25% error bands for the model and the grand mean of the model is well within the two standard error bands of the data. My results are consistent with the model implications for a sample of this size.

In summary, I am able to use replication and no arbitrage to substantially expand the span of data available to test models' predictions on the term structure of expected equity excess returns. The increase in span allows my data to cover a substantially larger number of business cycles in the post-1950 data and provide more consistent evidence on the basic term structure facts. I find that, across the board, my expanded dataset supports longer duration, or more distant, claims to the same firm carrying higher risk premia. My method is not limited to the market or rebalanced portfolios; it also expands the scope of the data to any cross-sectional portfolio. I examine the results of applying my method to the book-to-market sorted cross-section in the following section.

1.4.4 Term Structures in The Cross-Section

I discuss in Section 1.1.1 that one approach in the literature to addressing the term structure facts is to expand the scope of the data. My method allows me to contribute to this area as well by delivering estimates of the risk premium term structure comparable to those of the previous section for a variety of cross-sectional portfolios as well. For the cross-section I focus primarily on the buy-and hold portfolio results because these better represent the outcomes of a firm and rebalancing is more likely to have a strong effect for the cross-sectional portfolios, which my results confirm. Section 1.4.1 shows that the replication exercise is of similarly high quality to the market for each of these portfolios and horizons. Table 1.10 presents the results for the buy-and-hold book-to-market sorted cross section, while Table 1.11 presents the rebalanced results for completeness and comparison. I focus on the book-to-market sorted cross-section and present the results for other cross-sections with significance estimates in Appendix A.5.

The results are qualitatively similar to those for the rebalanced market. All the cross-sectional portfolios appear to display an upward sloping term structure in both the continuation claims and the cumulative strips in buy-and-hold portfolios. Further, strip returns are below asset returns and continuation returns are above asset returns across the board. This reinforces the conclusion that short duration payments carry lower risk premia. The results for rebalanced portfolios in the cross section are broadly the same and continue to support an upward sloping risk premium curve. The only result that does not strongly support an upward sloping risk term structure is the lack of an upward slope within the rebalanced growth portfolio cumulative strip returns. These dividend claim returns are still well below the asset return and the continuation claim returns remain above the asset return, which supports an overall upward slope to the curve despite the mixed slope early on.

Two other features of the cross-sectional results are notable, and help to explain the low slope of the growth dividend risk premium curve. First, the extreme portfolios display much greater differences between the rebalanced and buy-and-hold portfolio formation methods. The results for growth show a shallower, hump-shaped slope of returns within the strips, while the results for value show a substantially steeper slope relative to their buy-and-hold equivalents. This is consistent with the evolution of firm risk documented by [21], where value firms tend to de-risk over time while growth firms tend to become riskier. This makes the buy-and-hold value slope shallower and the growth slope steeper. Rebalancing offsets the firms' risk evolution, keeping the risk high for value over time and the risk low for growth and delivering a much higher slope for one and lower for the other. This also justifies my focus on buy-and-hold portfolios to estimate the within-firm risk premium curve because it is apparent that rebalancing alters the risk of the portfolio relative to the risk of the underlying firms. The second feature of note is that firms in the cross-section have different amounts of cash flow risk, not just different cash flow timing. This is especially evident for the rebalanced growth versus rebalanced value, where the strip curves and slopes are dramatically different. This supports a common mechanism used to generate differences in risk premia in the cross-section in the literature, i.e. different levels of cash flow risk.

1.4.5 Term Structures in Subsamples

In section 1.4.3 I present evidence that seems to conflict with existing research on the term structure of equity returns, finding strong and consistent evidence of an upward slope. It is possible that the post-2002 subsample for which dividend strip data is available contains too few business cycles to accurately estimate the unconditional mean excess return with the sample average. This argument is expanded on extensively in Bansal, Miller, Song, and Yaron [8] using the strip

Table 1.10: Term Structures of Excess Returns - Buy-and-Hold Cross Section

	Asset	Claim Horizon				
		1	2	3	4	5
Growth $E[R^n_{p,1} - R^1_{f,0}]$	6.05%	6.20%	6.42%	6.58%	6.81%	7.38%
Core $E[R^n_{p,1} - R^1_{f,0}]$	7.60%	7.85%	8.25%	8.50%	8.86%	9.38%
Value $E[R^n_{p,1} - R^1_{f,0}]$	10.83%	11.26%	11.78%	12.28%	12.88%	13.49%
Growth $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−2.19%	−0.30%	1.28%	1.60%	1.19%
Core $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−3.45%	−0.73%	1.20%	2.13%	1.60%
Value $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−4.71%	−0.45%	1.94%	3.00%	2.25%

Notes: I present results for the book-to-market sorted cross-section of buy-and-hold portfolios. Portfolio vintages are formed monthly based on 6 month lagged accounting data but are otherwise formed as in Fama and French [28]. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2 (Growth), 5 (Core), and 9 (Value) portfolios.

Table 1.11: Continuation Claim Excess Returns - Rebalanced Cross Section

	Asset	Claim Horizon				
		1	2	3	4	5
Growth $E[R^n_{p,1} - R^1_{f,0}]$	6.50%	6.63%	6.71%	6.79%	7.23%	7.73%
Core $E[R^n_{p,1} - R^1_{f,0}]$	7.55%	7.83%	8.10%	8.58%	9.07%	9.21%
Value $E[R^n_{p,1} - R^1_{f,0}]$	11.13%	11.63%	12.23%	12.38%	12.20%	12.61%
Growth $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−2.82%	0.46%	1.86%	0.90%	0.57%
Core $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−2.69%	−0.45%	0.61%	1.25%	2.49%
Value $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−2.41%	1.04%	5.80%	7.51%	8.12%

Notes: I present results for the book-to-market sorted cross-section of rebalanced portfolios. The data is the decile portfolio data constructed as in Fama and French [28] as presented on Kenneth French's webpage. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2 (Growth), 5 (Core), and 9 (Value) portfolios.

data, who argue that when the balance of good and bad times is misrepresented in a subsample the sample mean can be a biased estimate of the unconditional mean and give evidence that this is the case in the recent subsample. My method allows a direct comparison of the impact of subsampling from only the recent years on the means, while limiting the possibility that the data is contaminated by illiquidity. To investigate indicative results, I compute the mean excess returns based on the full-sample replication, but only the return realizations from post-2004 in Table 1.12. I use the post-2004 subsample due to the availability of dividend strip data in that sample, from which I construct the cumulative strip returns in the derivative data. This derivative data is discussed in Bansal, Miller, Song, and Yaron [8] and is provided by a major financial intermediary in the OTC strip markets for S&P 500 dividends. Table 1.12 shows that the qualitative results for returns are similar between the replication in the short sample and the dividend strip derivatives, which is confirmed by a 76% correlation of the derivative and replicated prices in this sample at horizon 1.

There are important differences between the point estimates in Table 1.12 relative to the full sample - differences that are immediately visually evident when comparing Figures 1.6 and 1.7. The shortness of the small sample renders most of the differences statistically insignificant, but the consistency of the results and economic significance of the magnitudes are both telling. The differences between the continuation claims and the asset are generally much smaller and universally statistically insignificant, implying a much higher risk premium for the first dividend claim in the subsample. The cumulative dividend claim returns bear this out, being 3-6% higher than their overall mean in this subsample. Unlike the full sample, the cumulative dividend claim returns are relatively close to the asset return, rather than substantially below it, and cross it before horizon 5.

The term structure slope within the continuation claims is also much shallower, implying that the early dividend claims are not as far below the asset return as in the full sample and may cross it earlier, which again is borne out in the cumulative dividend claims. While estimation noise and the shortness of the sample make the differences for statistically insignificant for most horizons, this indicates the strong possibility that the particular subsample for which strip data is available may not have a subsample mean term structure consistent with the unconditional mean. A possible reason for the much higher strip risk premia observed in this sample is the presence of the 2008 recession. In Table 1.14 I present the mean returns of the continuation claims and cumulative strips produced by my method in the subsample starting in recessions or booms over the full sample. In recession, these returns are much higher for both strips and continuation claims across horizons, but the difference is considerably larger for the strips. This supports the conclusion that the presence of a major recession in this relatively short sample may substantially raise the mean strip returns relative to their unconditional mean. The possibility of bias introduced by the short sample makes the expansion of time series span offered by my method all the more valuable in using term structure data to falsify the unconditional predictions of a model.

The conditional results also identify additional dimensions along which the data aligns with a standard model's predictions. In Table 1.14 I show that the replicated returns to both continuation and cumulative dividend claims are upward sloping in both recessions and booms, but are higher and steeper in recessions. This is exactly the prediction of a model like that presented in Section 1.2.3. The reason for this is that the unconditionally upward-sloping returns in such a model are driven

Table 1.12: Term Structures of Dividend Claim Excess Returns - Recent Sub-Sample

	Sample		Claim Horizon				
		Asset	1	2	3	4	5
Replication $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	2004-2012	5.26%	3.23%	2.99%	4.69%	6.15%	7.18%
Futures $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	2004-2012		2.48%	3.35%	4.13%	5.11%	6.11%

Notes: I present results for the CRSP rebalanced market of the mean excess returns of the asset and the estimated excess returns cumulative dividend claim. The cumulative dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute the regression coefficients and from 12/2004 to 6/2012 to compute the mean excess returns.

by the increasing dividend beta to the priced states by horizon (see Equations (A-22) and (A-23) in Appendix A.3). Thus a temporarily high risk premium with nonnegative persistence raises the expected excess returns of all claims, and more so for longer term claims. In Table 1.13 I show that the mean cumulative returns, discount rates, follow the pattern documented in Bansal, Miller, Song, and Yaron [8], upward sloping overall and in expansions and strongly downward sloping in recessions. While this represents another dimension along which the replicated data is consistent with existing work, it is also consistent with a model in which risk premia vary and that variation is persistent, as in the affine SVVAR. When risk premia are high, they are expected to mean revert. Despite the next period returns to longer dividend claims rising by more because of their cash flow beta, long horizon cumulative returns are lower because the risk premium mean reverts. In sum, the conditional results are also consistent with the predictions of a standard macro-finance model and the existing literature.

Table 1.13: Term Structures of Cumulative Returns (Discount Rates) - Sub-Samples

	Claim Horizon				
	1	2	3	4	5
	Continuation Claims				
Unconditional (Rep.) $E[R^n_{p,n}]$	11.91%	11.95%	11.94%	11.84%	11.91%
Recession (Rep.) $E[R^n_{p,n}]$	20.69%	16.14%	15.04%	13.46%	14.63%
Boom (Rep.) $E[R^n_{p,n}]$	10.41%	11.22%	11.40%	11.56%	11.42%
	Cumulative Dividend Claims				
Unconditional (Rep.) $E[R^n_{d,n}]$	2.00%	4.05%	5.09%	5.71%	5.81%
Recession (Rep.) $E[R^n_{d,n}]$	17.05%	11.11%	10.74%	10.76%	10.49%
Boom (Rep.) $E[R^n_{d,n}]$	−0.57%	2.80%	4.06%	4.77%	4.93%

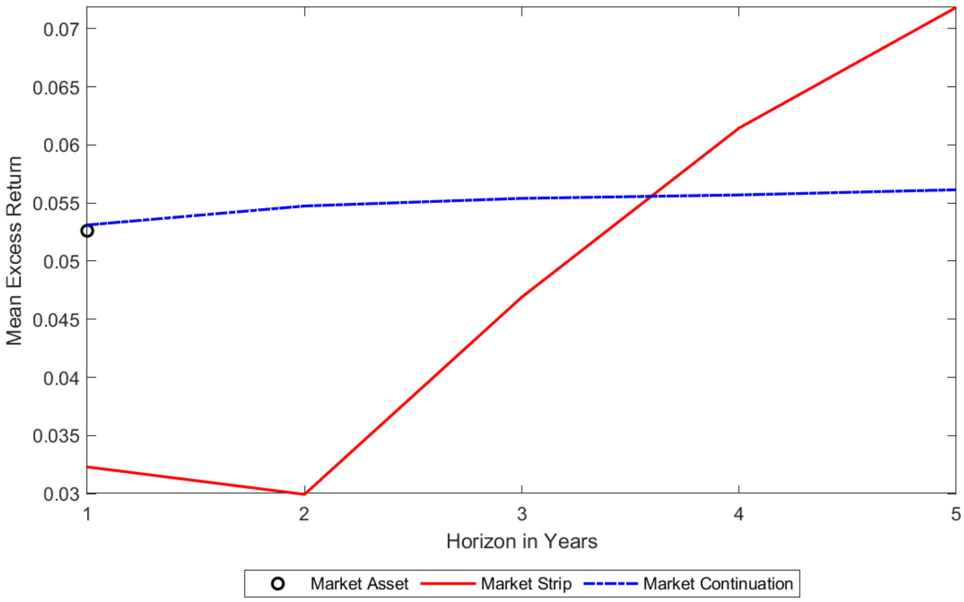
Notes: I present results for the CRSP rebalanced market of the estimated mean cumulative returns of the continuation and dividend strip claims. The continuation claim returns are given by $\hat{R}^n_{p,n} = \frac{P_n}{\hat{\Pi}^n_{p,0}}$ and the cumulative dividend claim returns by $\hat{R}^n_{d,n} = \frac{D_n}{\hat{\Pi}^{n-1}_{p,0} - \hat{\Pi}^n_{p,0}}$. I use monthly formation dates from 6/1950 to 6/2012 to compute the regression coefficients and I compute the mean cumulative returns unconditionally and conditional on starting in a recession over the full 6/1950 to 6/2012 sample.

Table 1.14: Term Structures of Excess Returns - Sub-Samples

	Claim Horizon				
	1	2	3	4	5
	Continuation Claims				
Unconditional (Rep.) $E[R^n_{p,1} - R^1_{f,0}]$	6.82%	7.13%	7.45%	7.88%	8.56%
Recession (Rep.) $E[R^n_{p,1} - R^1_{f,0}]$	13.85%	14.02%	14.20%	14.53%	15.20%
Boom (Rep.) $E[R^n_{p,1} - R^1_{f,0}]$	5.56%	5.89%	6.23%	6.68%	7.36%
	Cumulative Dividend Claims				
Unconditional (Rep.) $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	−3.19%	−1.63%	−0.55%	−0.17%	−0.40%
Recession (Rep.) $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	10.58%	13.03%	14.44%	14.74%	14.23%
Boom (Rep.) $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	−5.67%	−4.27%	−3.25%	−2.85%	−3.03%

Notes: I present results for the CRSP rebalanced market of the estimated mean annual excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the cumulative dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute the regression coefficients and I compute the mean annual excess returns unconditionally and conditional on starting in a recession over the full 6/1950 to 6/2012 sample.

Figure 1.7: Continuation Claim Excess Returns - Recent (2004-2012) Sample



Notes: I present results for the CRSP rebalanced market of the mean excess returns of the asset and the estimated excess returns of the continuation claim and cumulative dividend claim. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the cumulative dividend claim returns by $\hat{\hat{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \Pi^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute the regression coefficients and from 12/2004 to 6/2012 to compute the mean excess returns.

1.5 Conclusion

In this study I contribute to the fast-growing literature on the term structure of equity risk premia by introducing empirical methods based on replication and no-arbitrage that dramatically expand the span and scope of the data available to use in estimating risk premium term structures. I show that a reliable and parsimonious replication of the payoffs of claims to a firm's capital gains or continuation value can be achieved with three factors: firm returns, firm dividend to price ratios, and their interaction. I demonstrate the success of this method in a standard theoretical environment, showing a high replication R-squared and faithful reproduction of the price series. I then apply the method to the market and cross section of U.S. equity securities and show that the faithful replication of continuation claim payoffs is also possible in practice. Using the no-arbitrage prices of these payoffs implied by the replication, I am able to estimate a time series of realized returns to claims to a firm's continuation value at various horizons in the future. The term structure of these claims' as well as their corresponding cumulative dividend claims' risk premia relative to each other and their underlying asset strongly support more distant or longer duration claims carrying larger risk premia unconditionally. This is true both for the market and across a variety of cross-sections.

My conclusions are qualitatively consistent with the predictions of standard general equilibrium asset pricing models, and inconsistent with some of the existing derivatives-based literature and cross-sectional literature on risk term structures. I show two likely avenues that drive these differences, the effects of rebalancing on relatively small market subsections and the impact of using relatively short subsamples. In this study I focus exclusively on mean excess returns in order to preserve the parsimony of the replicating regressions. I conjecture that applying this method to price series conditioned on additional state variables may lead to productive future research on the conditional term structure of expected returns, volatility, and Sharpe Ratios. A core limitation facing researchers in the area of asset pricing term structures, the availability of long, liquid datasets that speak directly to the object of economic interest, can be substantively reduced with this simple exercise, providing useful avenues for future research.

Chapter 2

The Term Structure of Equity Risk Premia

2.1 Introduction

We use traded equity dividend strips from U.S., Europe, and Japan from 2004-2017 to study the slope of the term structure of equity discount rates.[1] We find, across all regions, that the term structure of dividend yields is upward sloping in expansions and downward sloping in recessions while the term structure of expected dividend growth rates is downward sloping in expansions and upward sloping in recessions. We develop a consumption-based regime-switching model (similar to [20] and [9]) which captures these regime-based data features. This regime-switching model, as in the [20] and [9] models, implies that the unconditional slope of the equity dividend risk-premium is positive. We use this model and the data on dividend strips to argue that the evidence on dividend discount rates, in contrast with the arguments made in [17], is entirely consistent with the positive slope implications of standard asset pricing models (Habits and Long Run Risks).

Existing research, [14], [15], [16], and [17], argues that "dividend strips data facts

[1] Chapter 2 of this dissertation is based on joint work with Ravi Bansal, Dongho Song, and Amir Yaron. This research was supported by Rodney White Center and Jacob Levy Center. We thank a major financial institution for supplying us the data. We also thank seminar participants at 2017 Macro-Finance Society Meeting in Chicago, Arizona State University, Duke University, Goethe University, HEC-Montreal-McGill, London Business School, London School of Economics, Stockholm School of Economics, University of California Berkeley, and the University of Michigan (Ann Arbor) for their comments. The views presented herein are those of the authors and not necessarily those of the Bank of Israel.

are difficult to reconcile with traditional macro-finance models." Using different modeling and data-analysis we arrive at an entirely different conclusion. We find considerable support in the data for the unconditional strip-yield implications of standard macrofinance models. Our data analysis differs from these papers on three fronts: (i) we use a somewhat longer historical sample and, unlike earlier papers, explicitly acknowledge that the short sample of dividend strip data, running from 2004 till 2017, does not accurately represent the long run balance of expansions and recessions, (ii) using the longer historical dividend sample we use Bayesian Vector Autoregression (BVAR) methods to conduct true out-of-sample analysis of growth rate forecasts and model comparisons and show that our conditional conclusions are robust to the elimination of look-ahead bias, and (iii) we focus on expected hold-to-maturity returns (i.e., dividend discount rates), which are robust to the illiquidity of this market, rather than monthly holding period returns, which also tend to be smaller than average bid-ask spreads. The difference in conclusions is driven largely by our analysis; while we have a somewhat longer data sample compared to [17], the overlapping period of our data set (which is most of the data) and that used in [17] is the same.

An important input in computing the discount rates and dividend risk premia for the dividend strips is a model for dividend growth rates. We conduct real-time forecasting of dividend growth rates by relying on a Bayesian Vector Autoregression (BVAR) framework which allows us to optimally exploit information in forecasting variables with longer histories (beyond our short sample) through priors. Our BVAR representation is general enough to nest forecasting models from the literature, enabling model selection via marginal likelihood comparison. We formally show that our approach, for example, has a higher marginal likelihood and superior forecast accuracy when compared to [15]. The use of predictors with longer data samples allows us to formally conduct out-of-sample forecasting analysis and demonstrate that the conditional conclusions are consistent with the in-sample analysis using either the long-sample predictors (LSP's) which are the focus of this paper or the short-sample predictors (SSP's) of previous work. Thus, our forecasting framework enables us to more precisely measure conditional variation in the expected growth and risk-premium term structures, variation which is robust to model specification and the elimination of look-ahead bias.

The expected hold-to-maturity returns (dividend discount rates) are measured by adding the observed dividend yields by maturity to the expected dividend growth rates by horizon. In terms of the key data findings we find that, across all countries, discount rates and dividend risk-premia rise with maturity during economic expansions and decline with maturity in recessions[2]. Expected growth rates, on the other hand, fall with maturity in expansions and rise with maturity in recessions. While these conditional aspects of the data are robust, the estimates (using 14 years of data) for the sample average slope of discount rates and growth rates are noisy and estimated with large standard errors. The average dividend risk-premium slope is positive for the U.S., zero for Japan, and negative for Europe. The average slopes are quite sensitive to the frequency of expansions and recessions; if the short sample oversamples recessions the average slope can

[2]Our evidence differs from that of [35] in the definition of macroeconomic expansions and recessions. We link good and bad times more closely to the macroeconomy by using peak-to-trough GDP growth measures commonly used to identify cycles, while Gormsen uses above or below median market price to dividend ratio to measure cycles. This latter measure overrepresents "bad times" by construction because it classifies 50% of the sample as bad times, where in the long run the economy spends 15% of the time in recession. Better identifying expansions and recessions allows for superior measurement of the conditional moments of expected returns and growth, which we show are economically sensible and consistent with standard models in contrast to the results in [35].

be negative even if its population value is positive. Indeed, in both Europe and Japan the short sample from 2004-2017 has a significantly higher frequency of recessions relative to their long run historical frequency. In the data the sample average discount rate slope is statistically significantly positive in the U.S., where recession frequency is in line with historical means, and is measured with large standard errors in Europe and Japan where recessions are overrepresented. We also observe, on average, a positive hold to matuirty Sharpe Ratio slope in the U.S.. While the Sharpe Ratio evidence is broadly consistent with the implications of standard models, it should be noted that these statistics are poorly measured in the data.

Consistent with the implications of the Habits and long run risks models, which generate a rising term structure of dividend risk premia, we develop a regime-switching model calibrated to the historical sample from the U.S. for recessions and expansions. We use this model to interpret the implications of dividend strip returns and yields for the term structure of macroeconomic risk. The population (long sample) dividend strip risk-premium in the regime-switching model rises with maturity. Further, the term structure of dividend risk premia is conditionally upward sloping in expansions and downward sloping in recessions. This model-implication is consistent with the data features discussed above. The model matches the average upward sloping dividend risk-premium curve for the U.S., whereas when the recession frequencies are too large relative to their population value, as is the case for Japan and Europe, the model generates the zero or negative slope found in the data. This establishes that a model with a positively sloped dividend risk-premium term structure (as in standard asset pricing models) matches the conditional and unconditional term structure of dividend strip risk premia observed in the data.

In our analysis we also focus on buy and hold-to-maturity returns on dividend strips—these returns are the economic object of interest as they correspond to discount rates for each dividend strip. Our focus on discount rates is motivated by practitioner oriented evidence discussed in [44] and [50], who highlight the fact that these markets are illiquid. Our more comprehensive dataset also includes expanded information on asset liquidity, specifically bid-ask spreads, unavailable in earlier studies. We show the transaction costs implied by bid-ask spreads are consistent with the conclusion of these articles that dividend strip markets are highly illiquid. The bid-ask spread on these contracts is larger than their monthly returns, the focus of previous studies, across horizons and regions and these contracts have very low liquidity compared to the futures market on the underlying equity index (e.g., S&P 500). This liquidity difference makes the comparison of the relative returns on the strips and the index extremely unreliable. Given the lack of liquidity in the strips we focus on expected hold-to-maturity returns, which we show mitigates the effects of large bid-ask spreads (i.e., trading costs).

Earlier work has also relied on other assets to provide evidence on the returns of strips, for example equity options in the case of [14]. This approach has drawbacks relative to direct evidence from strips. The options-based approach provides no evidence on the strip curve past two years, so it relies on comparing the index to the strips to infer the shape of the strip discount rate curve. [18] and [52] show why inference regarding dividend strips based on options data is suspect due to, respectively, micro-structure effects and tax issues. These studies, however, also use sample averages for unconditional inference. We show that correctly accounting for the balance of recessions and expansions makes the data entirely consistent with standard models and that market illiquidity can be appropriately addressed by focusing on hold-to-maturity expected returns[3].

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, [43] examines the implications of recession recovery for the term structure. [1] 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 [25] and [12] also find that the dividend strip and consumption strip risk premium curves need not coincide if dividend beta to consumption risk changes by horizon. More generally, [38], [3], and [51] study implications of various asset pricing models for different cashflow durations.

[3]Existing work, e.g. [59], studying discount rates and asset duration from the panel of equities is uninformative on term structure variation in discount rates because it assumes a constant discount rate between firms and across maturities.

2.2 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. Note that log-transformed variables are indicated with lower case letters.

2.2.1 Equity as 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

$$S_t = \sum_{n=1}^{\infty} P_{n,t}, \tag{2.1}$$

where $P_{n,t}$ 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 $P_{n,t}$ as

$$P_{n,t} = E_t \left[M_{t+n} D_{t+n} \right], \tag{2.2}$$

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

$$R_{n,t+1} = \frac{P_{n-1,t+1}}{P_{n,t}}. \tag{2.3}$$

Note that for $n = 1$, the dividend strip return is equal to $R_{1,t+1} = \frac{P_{0,t+1}}{P_{1,t}}$. The price of a claim on the current dividend is the value of the dividend itself which implies $P_{0,t+1} = D_{t+1}$. 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.

Using the 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:

$$R_{t+1} = \sum_{n=1}^{\infty} \frac{P_{n-1,t+1}}{S_t} = \sum_{n=1}^{\infty} \frac{P_{n,t}}{S_t} \frac{P_{n-1,t+1}}{P_{n,t}} = \sum_{n=1}^{\infty} \frac{P_{n,t}}{S_t} R_{n,t+1} = \sum_{n=1}^{\infty} \omega_{n,t} R_{n,t+1} \quad (2.4)$$

where $\omega_{n,t}$ 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.

2.2.2 Relation to Dividend Futures

Dividend futures are agreements where, at time t, the buyer and the seller agree on a contract price of $F_{n,t}$ 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 $y_{n,t}$ be the time t zero-coupon bond yield with maturity n. Then, the futures price is given by

$$F_{n,t} = P_{n,t} \exp(n y_{n,t}), \quad (2.5)$$

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

$$R_{n,t+1} = \frac{F_{n-1,t+1}}{F_{n,t}} \frac{\exp(-(n-1)y_{n-1,t+1})}{\exp(-ny_{n,t})}. \tag{2.6}$$

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

$$e_{n,t} = \frac{1}{n}\ln\left(\frac{D_t}{P_{n,t}}\right) \tag{2.7}$$

$$e^f_{n,t} = \frac{1}{n}\ln\left(\frac{D_t}{F_{n,t}}\right) = e_{n,t} - y_{n,t}. \tag{2.8}$$

2.2.3 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:

$$R_{t+n} = \frac{D_{t+n}}{P_{t,n}} = \frac{D_t}{P_{t,n}}\frac{D_{t+n}}{D_t}. \tag{2.9}$$

This is the n-period return on the dividend strip with time to maturity n, which relies on the same expression provided in (2.3). For notational simplicity, R_{t+n} is used instead of $R_{n,t+n}$.

Denote the n period average log return on an n period strip as $r_{t+n} = \frac{1}{n}\ln(R_{t+n})$ and the n period average dividend growth as $g_{d,t+n} = \frac{1}{n}\ln(\frac{D_{t+n}}{D_t})$. Rearranging

(2.9) by applying (2.7) and (2.8), we can rewrite the return decomposition as:

$$r_{t+n} = e^f_{n,t} + y_{n,t} + g_{d,t+n} = e_{n,t} + g_{d,t+n}. \tag{2.10}$$

Therefore, the average expected return is

$$E_t[r_{t+n}] = e_{n,t} + E_t[g_{d,t+n}] \tag{2.11}$$

which is the sum of the spot equity yield and the average expected dividend growth rates

$$E_t[g_{d,t+n}] = \frac{1}{n} E_t[\ln{(\frac{D_{t+n}}{D_t})}]. \tag{2.12}$$

(2.11) is referred to as the hold-to-maturity expected return, which is the conditional discount rate on the strip. Note that $e_{n,t}$ is an inflation neutral quantity, so using an estimate of real growth for $E_t[g_{d,t+n}]$ yields an estimate of real discount rates $E_t[r_{t+n}]$, 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 (2.11)

$$E_t[rx_{t+n}] = E_t[r_{t+n}] - y^r_{n,t}. \tag{2.13}$$

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

$$V_t[r_{t+n}] = V_t[g_{d,t+n}]. \tag{2.14}$$

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 strip conditional on the time t information set as:

$$SR_{n,t} = \frac{E_t[rx_{t+n}]}{\sqrt{V_t[g_{d,t+n}]}}. \tag{2.15}$$

Note that we are not accounting for the half variance term in defining excess returns.

2.3 Data

2.3.1 Data Source

Dividend Futures Prices

The data set covers the period from December 2004 to February 2017 at daily frequency and is provided from the proprietary data of a major financial institution that is active in dividend strips markets. The data consists of pricing and liquidity information on dividend futures. Dividend futures contracts typically mature on or after the third Friday of December in the year they mature. On that date 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. The data is the internal pricing information used to trade in these markets by the providing institution and the data delivered to us by the institution contains MID prices for the entire sample and BID and ASK prices for a slightly shorter sample - starting in July 2008 for the Eurostoxx, in June 2010 for the Nikkei, and in January 2010 for the S&P 500. The main data set that is used to calculate equity yields and returns corresponds to MID prices on the last trading day of the month.

Daily exchange traded volume and open interest are available for Eurostoxx and Nikkei for the same period as BID and ASK prices are available[4]. We also show that for the overlapping periods our data is consistent with that used in [15] and [17] in terms of descriptive statistics. The S&P 500 contracts are only traded over

[4]For much of the post-2010 period data on exchange traded volume, open interest, BID, and ASK prices are also available daily via Bloomberg as well for the Eurostoxx and Nikkei, although we use the institution provided data throughout.

the counter (OTC) and no comparable public data is available for the spreads on these contracts. Practitioner oriented work in [50] provides data on the volume traded and contracts outstanding in the OTC portions of each market that shows qualitatively consistent evidence on the liquidity of these markets. Section 2.5 discusses the liquidity data for these markets in detail.

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. For example, 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 $F_{17,t}$ and $F_{29,t}$, similar to the process used in [15].[5] When we compute holding period returns we interpolate between the returns themselves, thus obtaining a portfolio return for a portfolio with the same average maturity as the desired contract. This makes our estimates of holding period returns, particularly spread adjusted returns, achievable portfolio returns as in [16].

Zero-coupon Bond Yields

As can be seen from (2.6), 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. In order to ensure a consistent methodology is used in constructing the zero coupon interest rate curve we use the Bloomberg zero curve estimates for all three regions, for the dollar, yen, and

[5]We emphasize that our results are robust to yield interpolation instead of price interpolation method.

for euro-denominated German sovereigns. To extend the data further back than these estimates exist, we use the bond yield data from [37] available on FED's website. We obtain maturities at monthly frequency by linearly interpolating between available yields.

Dividend Growth Rates

We measure realized dividends from index returns. We use realized dividend data to construct dividend growth series starting in December 1979 for the U.S. and December 1994 for Europe and Japan, where the extended sample is reduced due to data availability. We provide the time series of the annualized dividend growth rates in the appendix as Figure A.2 for each region.

Recession Frequency

Our most dramatic finding in the data is the stark and robust variation of return and growth term structures across the business cycle. Importantly, we do not use recession or expansion state in forecasting but simply to subsample forecasts and data to emphasize cyclical variation. To identify business cycles we use the NBER recession dates for the U.S., the CEPR recession dates for Europe, and recession dates from the Economic Cycle Research Institute for Japan[6]. Substantial variation in slope across the cycle means that the frequency of recessions in a given short sample can substantially affect the sample mean of the slope. We document that in the sample with strips data, 2005-2017, the frequency

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

Table 2.1: Forward Equity Yields: Summary Statistics

n	1y	2y	3y	4y	5y	5y-1y	(t-stat)
				Panel A: S&P 500			
Sample average	-5.08	-4.55	-4.19	-4.01	-3.88	1.20	(0.68)
Expansion average	-7.15	-5.99	-5.17	-4.77	-4.52	2.63	(2.52)
Recession average	18.19	11.68	6.80	4.54	3.33	-14.86	(-6.71)
				Panel B: Eurostoxx 50			
Sample average	1.94	3.11	2.70	2.28	1.94	-0.00	(0.00)
Expansion average	-2.74	-0.92	-0.12	0.19	0.29	3.02	(2.34)
Recession average	18.10	17.04	12.42	9.48	7.64	-10.47	(-2.94)
				Panel C: Nikkei 225			
Sample average	-1.48	-1.47	-1.86	-1.85	-1.73	-0.26	(-0.13)
Expansion average	-6.26	-5.65	-5.18	-4.65	-4.17	2.09	(2.41)
Recession average	10.47	8.97	6.46	5.14	4.35	-6.12	(-1.57)

Notes: Equity yields are constructed by $e^f_{n,t} = \frac{1}{n}\ln(\frac{D_t}{F_{n,t}})$ with $F_{n,t}$ the futures price and D_t the trailing sum of 12 month dividends. We provide the subsample average and standard deviation of the forward equity yields from 2004:M12 to 2017:M2 for the three markets, i.e., S&P 500, Eurostoxx 50, and Nikkei 225. We partition the sample into "expansion periods," and "recession periods." For US, NBER recession dates are 1980:M1-1980:M7, 1981:M7-1982:M11, 1990:M7-1991:M3, 2001:M3-2001:M11, 2007:M12-2009:M6. For Europe, CEPR recession dates are 2008:Q1-2009:Q2, 2011:Q3-2013:Q1. For Japan, recession dates are 1998:M6-1998:M11, 2001:M9-2002:M5, 2008:M9-2009:M8, 2011:M3-2013:M2, 2014:M9-2015:M2. t-statistics are based on Newey-West standard errors. Maturities are in annual units.

of recessions is 12% in the U.S., 26% in Europe, and 36% in Japan. For the U.S., this is relatively close to the long run recession frequency since 1950 of 14%, but it is nearly double the rate for Europe, which was 13% in the long run, and Japan, which was 19%. This strongly suggests that the behavior of any cyclical slopes in Europe and Japan will be substantially biased towards their recession means in the data. We address this formally in a model in Section 2.4, but emphasize the recession and expansion subsample means throughout our exposition of the data evidence to reinforce the importance of recession frequency.

2.3.2 The Stylized Facts About Equity Yields and Dividends

Table 2.1 provides the summary statistics of the forward equity yields in these three markets from 2004 to 2017. We first look at the average term structure of equity yields. We find that only the U.S. market seems to show the evidence of upward sloping term structure of equity yields whereas the European and Japanese markets exhibit mildly downward sloping term structure of equity yields.

We then highlight the behavior of equity yields conditional on the state of business cycle, i.e., expansion and recession. There is remarkable consistency across these three markets. We find that the term structure of equity yields is upward (downward) sloping in expansion (recession) in all three markets. The absolute magnitude of the spread between 5-year and 1-year maturity equity yields tends to be much larger during recession than expansion.[7] One can easily deduce from this finding that the unconditional (sample) average of the term structure of equity yields heavily depends on the frequency of recession in the sample.

We will ultimately use a longer sample in forecasting dividend growth rates so that we can conduct real time out-of-sample forecasting, so we present results for both this extended sample and the subsample with strip data. The extended sample begins in 1979 for the U.S. and 1994 for Europe and Japan, due to data availability. Figure A.2 provides the time series of the realized dividend growth rates conditional on the state of the business cycle for the three markets. Note that there were no recessions identified by CEPR in Europe from 1994-2005. We emphasize first that the frequency of recessions in Europe and Japan after 2005

[7] The downward sloping pattern of the term structure is most notable during the Great Recession, see Figure A.1.

is greater than that in the longer sample, while it is comparable for both samples in the U.S., and second that the behavior of expected dividend growth rates, as documented below, is different in recessions and expansions. Given the behavior of the strip yields in Table 2.1, this implies that the sample average behavior if the various term structure slopes will be tilted towards thair recession outcomes in Europe and Japan.

2.4 The Regime-Switching Model

Motivated by the empirical findings, we introduce a regime-switching consumption-based asset pricing model to understand its implications for both the conditional and unconditional moments.

2.4.1 Cash Flow Dynamics

The joint dynamics of monthly consumption and dividend growth are

$$\begin{aligned} \Delta c_t &= \mu(S_t) + x_t + \sigma_c \eta_{c,t}, \quad \eta_{c,t} \sim N(0,1), \\ \Delta d_t &= \bar{\mu} + \phi(\Delta c_t - \bar{\mu}) + \sigma_d \eta_{d,t}, \quad \eta_{d,t} \sim N(0,1), \\ x_t &= \rho x_{t-1} + \sigma_x(S_t)\epsilon_t, \end{aligned} \tag{2.16}$$

where $\bar{\mu}$ is the unconditional mean of consumption growth, x_t is the persistent component of consumption growth, and S_t is a discrete Markov state variable that takes on two values $S_t \in \{1, 2\}$. We assume $\mu_1 > \mu_2$ without loss of generality and indicate $S_t = 1$ an expansion state and $S_t = 2$ a recession state.

The model-implied average expected dividend growth is

$$E_t[g_{d,t+n}] = \frac{1}{n} E\big[\sum_{i=1}^{n} \Delta d_{t+i} | S_t\big]. \tag{2.17}$$

The agent in the model observes the current regime, S_t, and makes forecast of future regime, S_{t+i}, based on the transition matrix

$$\mathbb{P} = \begin{bmatrix} p_1 & 1-p_1 \\ 1-p_2 & p_2 \end{bmatrix}. \tag{2.18}$$

It is easy to understand from (2.17) that the path of $E_t[g_{d,t+n}]$ significantly depends on the current state S_t. To provide a preview, the slope of the expected dividend growth is negative (positive) if the economy is in expansion (recession). This is illustrated in Figure 2.1. Later, we argue that the model characterizes an important aspect of the data especially when it comes to the short-horizon forecasts.

2.4.2 Stochastic Discount Factor

We assume that the log stochastic discount factor (SDF) follows

$$m_{t+1} = -r_{t+1} - \frac{1}{2}\lambda(S_{t+1})^2 - \lambda(S_{t+1})\epsilon_{t+1} \tag{2.19}$$

with an exogenously specified risk-free rate, r_{t+1}. We set $r_{t+1} = \bar{r}$ so that the risk-free rate does not depend on the state. The market price of risk depends on the state $\lambda(S_{t+1})$. We impose that $\lambda(1) < \lambda(2)$ in the spirit of [20], e.g., higher risk aversion in bad times. Since $\mu_1 > \mu_2$, this allows us to match the recession and expansion dynamics of both returns and growth while preserving the implications of standard models. In both Habits and long run risks, short term risk goes up in bad states then gradually comes down over time, generating the conditional features we have explicitly modeled in this regime-switching model in a simpler implementation. Along with capturing expected growth variation in a convenient way that is consistent with the data, an improvement relative to standard calibrations, this will also allow us to match the conditional yield and dividend discount rate slopes.

2.4.3 Price to Dividend Ratio of the Zero-Coupon Equity

The price of zero-coupon equity is $P_{n,t} = Z_{n,t}D_t$. In the economy of (2.16) with the SDF of (2.19), we can conjecture that the log price to dividend ratio of the zero-coupon equity $z_{n,t}$ depends on the regime and persistent growth component, i.e., $z_{n,t} = z_{n,0}(S_t) + z_{n,1}(S_t)x_t$. Exploiting the law of iterated expectations, we can solve for $z_{n,t} = \ln E\big(E\big[\exp(m_{t+1} + z_{n-1,t+1} + \Delta d_{t+1})|S_{t+1}\big]|S_t\big)$. The detailed derivation is provided in the appendix.

2.4.4 Hold-to-Maturity Expected Excess Return

Define the m-month holding period return of the n-month maturity equity by

$$R_{n,t+m} = \frac{Z_{n-m,t+m}}{Z_{n,t}}\frac{D_{t+m}}{D_t}. \tag{2.20}$$

The average log expected return is

$$E_t r_{n,t+m} = \frac{1}{m}E_t[z_{n-m,t+m} - z_{n,t} + \sum_{i=1}^{m}\Delta d_{t+i}]. \tag{2.21}$$

When $m = n$, the equation (2.21) becomes the hold-to-maturity expected return of the n-month maturity equity. We show in the appendix that

$$e_{t,n} = -\frac{1}{n} z_{n,t} \tag{2.22}$$

and how to calculate $E_t[g_{d,t+n}]$, $z_{n,t}$, and $y^r_{n,t}$. It is then straightforward to compute (2.11), (2.13), and (2.15).

2.4.5 The Model-Implied Term Structure of Equity Risk Premia

We calibrate the model to match the U.S. data moments for consumption and dividend growth rates and market equity premium. The calibrated parameters for consumption growth are standard (the expansion state is associated with higher mean and lower volatility).

The Conditional Moments

Note that the conditional moments will be function of consumption growth component x_t and the regime (discrete state) S_t. For ease of illustrating the model implications, we set $x_t = 0$ for simplicity and highlight the role of regime S_t.[8] Panel A of Figure 2.1 provides the model-implied (2.7), (2.11), (2.12), and (2.13). We summarize the model implications as follow:

1. The slope of the expected dividend growth is negative (positive) if the economy is in expansion (recession).[9]

[8] This means that the risk associated with x_t is priced, but we assume that the realization is $x_t = 0$ for graphical illustration.

[9] One thing to emphasize is that the expected dividend growth rate is much lower in recession even though we calibrated $\mu_2 = 1.2\%$ (annualized). What matters is whether the current economic state is below the long-run mean $\bar{\mu}$ or not.

2. The slope of the term structure of the riskfree rate is zero (by construction).

3. The slope of the equity yields, dividend discount rates, and dividend risk premia is positive (negative) if the economy is in expansion (recession).

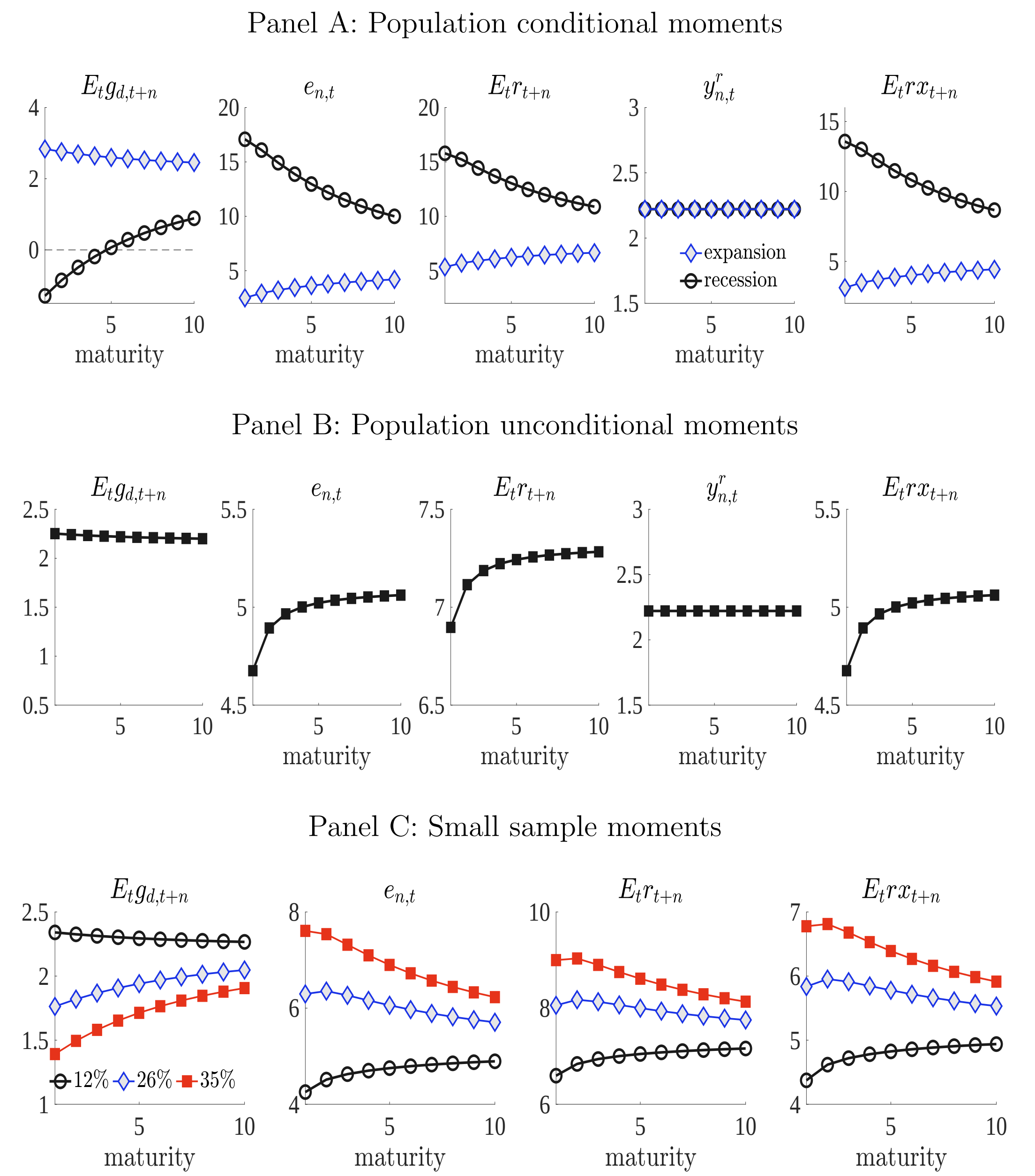
We match the key conditional expected growth rate and dividend discount rate slope features documented in the data in Tables 2.1 and **??**. We also calibrate the regime transition probabilities to match the long run frequency of recessions across regions - about 15%.

The Population Moments

Panel B of Figure 2.1 provides the population unconditional moments of the term structure of the equity risk premia and expected growth in the model. The model generates unconditional term structure of discount rate and equity risk premia in which both macroeconomic and dividend risk rises with horizon. Empirically speaking, the unconditional price and return moments can be hard to measure, since they involve calculating the unconditional probabilities of the state of the business cycle. The results depend on the sample over which the probabilities are calculated. The small sample bias is especially relevant in this context. For example, if recessions are overrepresented in the sample, then the sample average moments of prices and returns would be biased towards those in the recession state. Hence, there is substantial risk of misinterpreting the results if sample averages are used to estimate unconditional means without attention to the frequency of recessions.

To show this, we average the conditional moments implied from the model across the two states with recession frequency that is different from the steady state

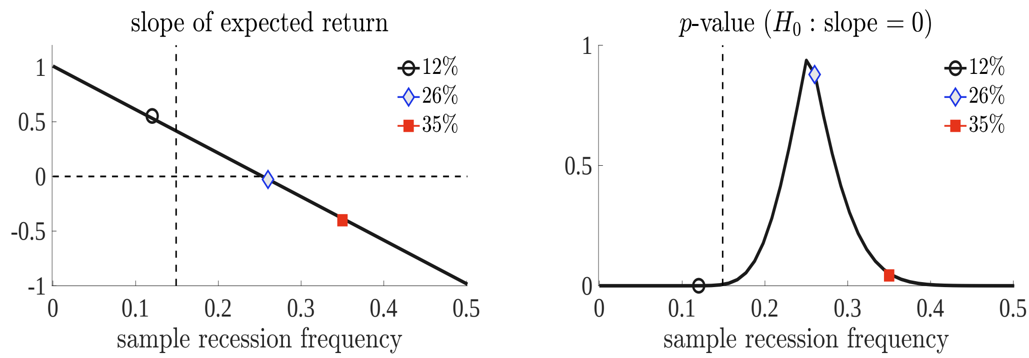
Figure 2.1: The Model-Implied Conditional Moments



Notes: We set $\mu(1) = 2.4, \mu(2) = 1.2, \sigma_c = 2.2, \rho = 0.50, \sigma_x(1) = 1.13, \sigma_x(2) = 2.41$, $p_1 = 0.9965, p_2 = 0.98$. Dividend growth dynamics are set according to $\phi = 4, \sigma_d = 6$. The market price of risk is set to $\lambda(1) = 0.13$ and $\lambda(2) = 0.28$. The risk-free rate is 2.2. While we use a monthly model to compute these components, parameter calibration is reported in annualized term. Panel A and B - We examine the case of $x_t = 0$. Panel C - In the data, the recession periods were 12%, 26%, 35% of the sample from 2005:M1 to 2013:M2 for the U.S., Europe, and Japan, respectively. Motivated from this, we average the moments implied from the model across the two states with the probabilities obtained from the data to compute the sample averages.

probability of recession, which is around 15%. We proceed with three cases of recession frequency based on the realized short sample recession frequencies in

Figure 2.2: The 5y-1y Slope of Expected Returns from Simulations



Notes: We set $\mu(1) = 2.4, \mu(2) = 1.2, \sigma_c = 2.2, \rho = 0.50, \sigma_x(1) = 1.13, \sigma_x(2) = 2.41, p_1 = 0.9965, p_2 = 0.98$. Dividend growth dynamics are set according to $\phi = 4, \sigma_d = 6$. The market price of risk is set to $\lambda(1) = 0.13$ and $\lambda(2) = 0.28$. The risk-free rate is 2.2. While we use a monthly model to compute these components, parameter calibration is reported in annualized term. We simulate eight years of data T and repeat the simulation N=10,000 times. Thus, we have a panel $N \times T$ of the model-implied slope of expected return. We compute the average probability of recession for each time series. We then sort this N dimensional vector of recession probability from low to high. Starting from low to high recession probability, we report the sample average slope of expected return (first panel). We also test the null hypothesis that the slope of expected return is zero (second panel). In the data, the recession periods were 12%, 26%, 35% of the sample from 2005:M1 to 2013:M2 for the U.S., Europe, and Japan, respectively.

the three regions of 12%, 26%, and 35% of the sample from 2005:M1 to 2013:M2 for the U.S., Europe, and Japan, respectively. We use the prediction sample to estimate the recession probabilities. Panel C of Figure 2.1 provides the small-sample averages of the term structure of the equity risk premia and expected growth among others based on three cases of recession frequency. One could clearly observe the pattern of downward sloping term structure of discount rate and equity risk premia when recession frequency is much greater than the model steady-state recession frequency, as is the case in Europe and Japan in the data. If the small sample recession frequency is below the model steady state recession probability, then the term structure of discount rate and equity risk premia are strongly upward sloping, as is the case in the U.S. in the data.

Figure 2.2 pursues this idea more formally. We simulate the time series of economic state (recession and expansion) from the model that matches the length of our prediction sample, which is roughly eight years ($T = 96$ months). Conditional on the economic state at each time t, we pick the corresponding moments of expected return for the entire maturity from Panel A of Figure 2.1. We repeat the exercise by $N = 10,000$ times to provide variation in the realization of recession states. Thus, we have an $N \times T$ panel of the model-implied slope of expected return. Next, we compute the realized recession frequency for each simulated time series and sort the set of time series on the realized frequency. Starting from low to high recession probability, we report the sample average slope of expected return (first panel). We also test the null hypothesis that the slope of expected return is zero (second panel). Since the risk-free rate is constant in the model, this is equivalent to testing the slope of equity risk premia.

We cannot reject the null hypothesis, i.e., slope is zero, if recession frequencies are around 19%-33%. In this range, the corresponding p-values are greater than 10% at least. Once the recession frequency falls below 19%, the p-value approaches zero and the model-implied slope of expected return is statistically strongly positive. In contrast, if recession frequency is greater than 33%, the opposite is true. In the data, we find that the recession periods were 12%, 26%, 35% of the sample from 2005:M1 to 2013:M2 for the U.S., Europe, and Japan, respectively. From the perspective of our model, only the U.S. seems to show the evidence of upward-sloping term structure of expected return (discount rate) which is statistically significant. On the opposite end of the spectrum, Japan shows the evidence of downward-sloping term structure of expected return, which is statistically significant both in the model and the data. Despite the statistical significance of the slope, this is a poor estimate of the unconditional mean, which helps to rationalize the sample average slopes we observe in the data. Further, the model's prediction is qualitatively consistent with the forecasts of the slope of expected returns (the sample average) in Table ?? across regions.[10]

2.4.6 Summary of the Model

We introduced a standard no-arbitrage model extended with regime-switching growth dynamics, which inherits key features of the leading asset pricing models (e.g., long-run risks and habit formation models). The regime-switching growth dynamics produce conditional dynamics of expected growth and dividend discount rates consistent with data documented via the BVAR. The model generates unconditional discount rate term structures in which risk rises with horizon. We also show that, in spite of the unconditional upward slope, in finite samples the sample average dividend discount rate term structure can slope down when recessions are overrepresented, a key feature of the data. The model matches both the conditional and sample average slopes across regions when the recession frequenies match in the small sample. Based on these results we conclude that the implications of the Habits and Long Run Risks models are entirely consistent with the strip data. This is in direct contrast to the conclusions drawn by [17], among others, who rely directly on sample averages of monthly holding period returns as estimates of the unconditional term structure.

[10]The forecast of slope of expected dividend growth rates turns out to be statistically insignificant for all regions. Thus, we do not attempt to compare with the model counterpart.

2.5 Illiquidity and Holding Period Returns

Some of the literature on dividend strips relies on monthly holding period returns at the mid of bid and ask prices to estimate the term structure of dividend discount rates. We show that monthly dividend strip holding period returns are poorly measured, highly sensitive to spreads, and are smaller than average spreads almost universally. Based on these returns there are two claims (see [17]) - that the holding period returns decline with maturity and are below the index (implying a downward slope) and that Sharpe Ratios follow a similar pattern. In Table 2.2, below, we replicate this evidence for our dataset and show that these returns are measured with large standard errors at mid prices. More importantly, we show that holding period returns are contaminated by severe illiquidity as reflected in large bid-ask spreads. Indeed, spreads are larger than monthly returns, making these holding period returns unreliable for measuring the underlying discount rates of economic interest.

2.5.1 Holding Period Returns at Mid Prices

First, we reproduce the evidence on mean holding period returns at mid prices, the focus of earlier work. We examine whether the index is above or crosses the term structure of dividend strip returns and Sharpe Ratios and whether returns Sharpe Ratios rise with maturity. Table 2.2 displays the point estimates for returns in excess of the index and strip Sharpe Ratios for the S&P 500, Eurostoxx, and Nikkei. Table 2.2 shows that there is no significant difference between index and strip returns, even if the point estimates of dividend strip returns are below the monthly index for the S&P 500 but are above the monthly index for Nikkei and

Table 2.2: Dividend Strip Returns Less Market Return

Maturity		1-M	2-M	3-M	4-M	5-M	Asset
Panel A: S&P 500							
1-month-hold	average	-4.32	-2.31	-0.94	-0.06	1.33	6.58
	t-stat ($\neq 0$)	-1.24	-1.03	-0.40	-0.02	0.83	
	stdev of Strip	12.07	11.39	11.53	11.87	12.55	14.10
	Sharpe ratio of Strip	0.13	0.27	0.37	0.41	0.47	0.47
Panel B: Eurostoxx 50							
1-month-hold	average	2.70	2.90	2.10	1.89	2.05	4.28
	t-stat ($\neq 0$)	0.66	0.86	0.62	0.58	0.65	
	stdev of Strip	15.22	14.41	14.34	14.23	14.19	17.14
	Sharpe ratio of Strip	0.46	0.31	0.25	0.23	0.24	0.25
Panel C: Nikkei 225							
1-month-hold	average	2.29	2.25	3.82	5.40	6.28	7.63
	t-stat ($\neq 0$)	0.45	0.42	0.72	1.00	1.38	
	stdev of Strip	17.40	19.86	20.17	19.54	18.99	19.79
	Sharpe ratio of Strip	0.82	0.47	0.48	0.53	0.55	0.38

Notes: The time series of dividend strip returns less the market return $R_{M,t+1}$ is calculated as $R_{n,t+1} - R_{M,t+1} = \frac{F_{n-1,t+1}}{F_{n,t}} \frac{\exp(-(n-1)y_{n-1,t+1})}{\exp(-ny_{n,t})} - R_{M,t+1}$ with $F_{n,t}$ the futures price for maturity n and $y_{n,t}$ the risk free zero coupon bond yield for maturity n. Returns for maturities not currently traded are constructed from portfolios of returns on traded maturities. Means, standard deviations, and Sharpe Ratios are annualized for monthly hold periods. 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.

Eurostoxx. Strip returns slope up in the U.S. and Japan and down in Europe, a fact which is again insignificant. Finally, there are no significant differences in Sharpe Ratio, although the point estimates slope up and are below the index in the U.S. and slope down and are above the index elsewhere. As emphasized by [23], there is no reliable inference to be drawn from monthly holding period returns at mid prices because they are both poorly measured and have a short sample. The fact that average spreads are universally larger than returns in these markets casts a deeper pall on the reliability of the holding period return evidence, as we discuss next.

2.5.2 Illiquidity and the Level of Returns

Recent work by [50], who document the illiquidity of the strip market and its causes, and analysis in news media, e.g., [44], both suggest that these markets are highly illiquid and are dominated by liability hedging at long horizons. Motivated by these studies and the avilability of our novel dataset of spreads for the OTC S&P 500 strip market we directly examine the implications of spreads in these markets for mean holding period and hold to maturity returns and Sharpe Ratios. Note that our bid-ask data are the spread faced by a large financial institution trading in these markets, the data provider for the remaining data. The sample of spread data is shorter for all regions than the mid price data, starting in 2008-2010 across regions.

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

$$BA_{n,t} = \frac{F_{n,t}^{ask} - F_{n,t}^{bid}}{0.5 \cdot (F_{n,t}^{ask} + F_{n,t}^{bid})}. \tag{2.23}$$

Table 2.3 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. While short run Eurostoxx strips trade in the most liquid of these markets, the differences in liquidity by horizon are particularly large outside the U.S., increasing by a factor of between 3 and 8 for spread mean and 2.5-9 for spread volatility, from 1 to 5 years. Note that strongly increasing spreads and spread volatility with horizon will particularly contaminate evidence comparing the long and short end of the term structures of expected returns and Sharpe Ratios.

Table 2.3: Dividend Strip Bid-Ask Spreads

n	1y	2y	3y	4y	5y	Asset
Panel A: S&P 500						
Sample average	1.31	1.60	1.78	2.06	2.26	0.04
Standard deviation	0.57	0.68	0.74	0.77	0.84	0.05
Panel B: Eurostoxx 50						
Sample average	0.45	0.86	1.43	2.59	3.73	0.04
Standard deviation	0.46	0.91	1.40	2.98	4.89	0.02
Panel C: Nikkei 225						
Sample average	1.42	2.39	2.98	3.41	4.63	0.56
Standard deviation	0.99	2.02	2.36	2.16	2.47	0.47

Notes: The period starts in July 2008 for the Eurostoxx, in June 2010 for the Nikkei, and in January 2010 for the S&P 500, and ends in February 2017 for all. The time series of bid-ask spreads for dividend futures is calculated as $BA_{t,n} = \frac{F_{n,t}^{ask} - F_{n,t}^{bid}}{0.5 \cdot (F_{n,t}^{ask} + F_{n,t}^{bid})}$ with $F_{t,n}^{ask}$ the dividend futures ask price for maturity n and $F_{n,t}^{bid}$ the bid. Spreads are presented in percentages (multiplied by 100). Results are reported using monthly data. The period starts in July 2008 for Eurostoxx, in June 2010 for Nikkei, and in January 2010 for S&P 500, 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.

Importantly, bid-ask spread means are dramatically larger than 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. Further, all of these markets are substantially less liquid than the counterpart markets for short run index futures on the same indexes[11]. Liquidity differences contaminate comparisons both between markets and across maturities. Drawing conclusions on relative index and strip returns and Sharpe Ratios in the presence of such large illiquidity is highly unreliable. In comparison, index returns are relatively well measured, even accounting for spreads.

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

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 were to buy the dividend strip at the ask and sell at the bid on a monthly basis. We present the results of this analysis in Table 2.4. 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. 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.[12]

One way to mitigate the impact of large transaction costs is to increase the holding period. However, we find that 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 same order of magnitude as the mean return in all three markets. For longer maturity contracts it is still difficult to justify the assumption that the marginal investor intends to give up between 30% and all of the return on the contract by trading it at a 1 year horizon.

[50] reinforce the view that these markets are highly illiquid using trading volume and open interest information. They show that across exchanges and OTC markets, dividend futures trade in markets orders of magnitude smaller than their associated index futures, both in terms of notional and contracts outstanding.[13]..

[12]Investors may implement trading strategies that mitigate the impact of spreads but nevertheless these spreads reflect the considerable transaction costs that any investor would face.

[13]For instance, the Eurostoxx dividend futures market, the largest strip market, is less than

Table 2.4: Average Dividend Strip Spread-Adjusted Returns

Return		Maturity					Asset
		1y	2y	3y	4y	5y	
		Panel A: S&P 500					
1-month-hold	mid-price	2.91	6.76	8.45	9.34	9.94	12.43
	bid/ask spread-adj.	-12.84	-12.61	-13.07	-15.51	-16.95	-
hold-to-maturity exp.	mid-price	-0.44	-0.38	0.11	0.48	0.74	-
	ask-price	-1.02	-0.75	-0.19	0.22	0.54	-
		Panel B: Eurostoxx 50					
1-month-hold	mid-price	7.06	6.40	5.32	4.50	4.60	3.81
	bid/ask spread-adj.	1.00	-4.49	-11.35	-25.96	-38.96	-
hold-to-maturity exp.	mid-price	2.49	3.66	2.81	2.04	1.42	-
	ask-price	2.13	3.25	2.52	1.75	1.06	-
		Panel C: Nikkei 225					
1-month-hold	mid-price	8.71	12.78	15.76	17.73	18.77	13.68
	bid/ask spread-adj.	-8.62	-16.26	-19.99	-23.38	-36.67	-
hold-to-maturity exp.	mid-price	0.57	2.04	2.86	3.59	4.13	-
	ask-price	-0.16	1.48	2.35	3.11	3.59	-

Notes: The period starts in July 2008 for the Eurostoxx, in June 2010 for the Nikkei, and in January 2010 for the S&P 500, and ends in February 2017 for all. The asset is the monthly total return on the index used to settle the contract, less the spread on the nearest to maturity futures contract where appropriate. Dividend strip returns are computed as in (2.6) and spread adjusted dividend strip returns correspond to

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

where results are reported for maturities $n = 1, ..., 5$ years, and holding period of k=1, 12 month. Returns for maturities not currently traded are constructed from portfolios of returns on traded maturities. Hold-to-maturity expected returns are computed from the BMSY approach. Means and standard deviations are monthly annualized percentages. Maturities are in annual units.

Both [50] and [44] indicate that the issuers of structured notes are long these products to reduce their exposure to dividends. This suggests buy and hold liability hedging could be driving a considerable volume of trade.

Given the bid-ask spreads and [50]'s evidence, we mitigate the effects of illiquidity consistent with contracts held by hold to maturity investors. These investors

10% the size of the associated index futures market by notional. In addition [44] claims that U.S. domiciled traders could not invest in Eurostoxx markets until 2017. Note that [50]'s data is exclusively from 2015, when this market was relatively mature compared to the majority of the sample period, thus the liquidity of these markets was likely substantially smaller for most of the sample for which we have strip data.

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 to the greatest extent possible. We report the hold to maturity expected returns, 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 2.4. Within the sample for which spreads are available, spread adjusted expected returns also reflect the same qualitative and quantitative patterns as the expected returns unadjusted for transaction costs. Further, the level effect of transaction costs is small, consistent with the evidence presented and referenced above. 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 holding period return-based evidence.

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 implications of standard asset pricing models of short horizon dividend claims carrying less macroeconomic risk than long horizon claims. There is no reliable evidence supporting the existing claims of the literature because monthly holding period returns are both too poorly measured too illiquid to be useful for inference. 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.

2.6 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 and the limitations of the data. 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 that the term structure of dividend strip risk premia and discount rates implied by equity strip yields is downward sloping in recessions and upward sloping in expansion periods, a finding which is statistically significant and robust across regions, in and out of sample estimation, and predictive models. We also show that the frequency of recessions in the very short sample for which strips data is available is much higher than the long run recession frequency in both Europe and Japan.

We develop a regime-switching model that is consistent with the implication of leading models that the unconditional risk premium term structure slopes upwards and also matches the recession and expansion slopes of expected growth and returns. We show that when recessions are in line with the long run frequency in a short sample the discount rate term structure will be upward sloping, but when recessions are overrepresented the slope can be flat or negative as we see in the data for Europe and Japan. The regime switching model shows that the discount rate term structure evidence from dividend strips is consistent both conditionally and unconditionally with the implications of leading asset pricing models like habits or long run risks.

Finally, we show that dividend discount rates, the object of economic interest, are also the preferred focus for statistical and institutional reasons. First, holding period returns on the strips do not provide statistically significant evidence for or against any model, either via the term structure slope or comparisons against the asset return. Second, holding period returns are contaminated by the dramatic illiquidity of dividend strip markets, where average trading costs, bid ask spreads, are larger than monthly returns. Finally, we show that discount rates and their associated evidence are robust to these issues. In totality, we find strong evidence that all the robust features of the strip evidence are both conditionally and unconditionally consistent with the implications of leading asset pricing models.

Conclusion

In the preceding essays I show statistically strong and regionally and cross-sectionally robust evidence that the term structure of equity risk premia is unconditionally upward sloping and consistent with the core predictions of many major macro-finance models, e.g. [20] and [9]. This is in contrast to a number of recent studies that argue, using the sample mean slope from dividend strip or option data, that the term structure of risk is downward sloping. I argue that when using a dataset with a short time series span derived from a highly illiquid market it is essential to account for these limitations of the data when drawing inference, especially inference about unconditional data moments.

In Chapter 2 I show that while the unconditional moments of the term structure are poorly measured in the dividend strip data, the conditional moments can be well-measured and are consistent with an unconditionally upward-sloping term structure even if the sample mean term structure slopes downwards. This is because a small sample need not reflect the correct long run balance of recessions and expansions, and thus because the term structure of risk slopes upwards in expansions and downwards in recessions a small sample that overrepresents recessions will bias the estimated term structure slope downwards.

In order to address the short sample span and illiquidity of existing datasets I seek to use highly liquid data with a long time series span to investigate the term structure of risk in Chapter 1. There, I show that a low dimensional set of returns and state variables provide a close replication of claims to firm capital gains at different horizons and that the prices of these claims can be used to draw inference on the term structure of equity risk premia. I show that across

cross-sections and regions, the term structure implied by my replication and no-arbitrage methodology is upward-sloping and consistent with the predictions of many major macro-finance models. I then argue that the short sample for which dividend strips exist differs strongly from the long sample my method gives access to, but that the term structure implied by my method is consistent with the existing evidence within the sample for which the two datasets overlap. Thus, extending the span of the data drives the difference in results between my work and the existing literature, reinforcing the importance of addressing the weaknesses of a novel dataset when analyzing it for macroeconomic or asset pricing research.

Appendix A

Appendices

A.1 Multi-Period Claims

If the law of one price holds, the price of the stock, P_t, can always be written as the sum of the prices of claims to only the dividends delivered at a given horizon n, the dividend strips at horizon n, $\Pi^n_{d,t}$[1]:

$$1 = E[M_{t+1}R_{t+1}] = \frac{\Pi^1_{d,t} + \Pi^2_{d,t} + ... + \Pi^n_{d,t} + ...}{P_t} \tag{A-1}$$

It can also be written as a finite sum of dividend claims and a continuation claim:

$$P_t = \Pi^1_{d,t} + \Pi^2_{d,t} + ... + \Pi^n_{d,t} + \Pi^n_{p,t} \tag{A-2}$$

This is the standard decomposition of the firm price used in education and research. Dividing through by the price, we can see that $\Pi^n_{d,t}/P_t$ sums to 1, and the relative weights on each strip give the term distribution of the firm's value across cash flows delivered at different horizons. It is immediate that the term structure of $\Pi^n_{p,t}$ represents the same division of the asset price across horizons, it is simply the remaining piece after the intermediate dividends are stripped out.

[1] We can write the asset price in terms of the projections of the dividend claim prices onto the payoff space as well, see Hansen and Richard [41].

The prices of two adjacent claims to the continuation value of the firm differ by only a single dividend claim, that is $\Pi^n_{d,t} = \Pi^{n-1}_{p,t} - \Pi^n_{p,t}$. It is clear from comparing the decompositions that all the pricing information in the term structure of $\Pi^n_{d,t}$ is also contained in the term structure of $\Pi^n_{p,t}$ since there is always a sum of the two that reproduces the asset price. Note that this also implies we can write the return on the stock or a continuation claim as the return on a portfolio of dividend claims, and similarly for continuation claims:

$$R^n_{p,t+1} = \frac{\Pi^n_{d,t+1} + \Pi^{n+1}_{d,t+1} + \Pi^{n+2}_{d,t+1} + ...}{\Pi^{n+1}_{d,t} + \Pi^{n+2}_{d,t} + \Pi^{n+3}_{d,t} + ...} = \frac{\Pi^{n+1}_{d,t}}{\Pi^n_{p,t}} R^{n+1}_{d,t+1} + \frac{\Pi^{n+2}_{d,t}}{\Pi^n_{p,t}} R^{n+2}_{d,t+1} + \frac{\Pi^{n+3}_{d,t}}{\Pi^n_{p,t}} R^{n+3}_{d,t+1} + ... \tag{A-3}$$

Where the second equality arises from collecting the denominator then multiplying and dividing each term by $\Pi^m_{d,t}$ for the appropriate m. It is important that the continuation claim consists of all subsequent dividend claims, and is therefore longer duration, delivers more of its cash flows in the distant future, than all previous dividend claims.

Similarly, the multiperiod analogue of Equation Equation (1.3) shows how this term structure is used in the existing literature:

$$\frac{D_t}{\Pi^{n-1}_{p,t} - \Pi^n_{p,t}} = \frac{D_t}{\Pi^n_{d,t}} = E_t\left[\frac{D_{t+n}/\Pi^n_{d,t}}{D_{t+n}/D_t}\right] = E_t\left[\frac{R_{t,t+n}}{D_{t+n}/D_t}\right] \tag{A-4}$$

A.2 Proof of Capital Gains Decomposition

In this appendix I provide a detailed proof and explanation of the capital gains decomposition in Equation (1.6). Define the one period return as:

$$R_{t+n-1,t+n} \equiv \frac{P_{t+n} + D_{t+n}}{P_{t+n-1}} \tag{A-5}$$

We can then define a cumulative return as Equation (A-6) and substitute the definition in Equation (A-5) for each term:

$$R_{t,t+n} \equiv R_{t+n-1,t+n} \cdot R_{t+n-2,t+n-1} \cdot \ldots \cdot R_{t+1,t+2} \cdot R_{t,t+1} \tag{A-6}$$

$$R_{t,t+n} = \frac{P_{t+n} + D_{t+n}}{P_{t+n-1}} \cdot \frac{P_{t+n-1} + D_{t+n-1}}{P_{t+n-2}} \cdot \ldots \cdot \frac{P_{t+2} + D_{t+2}}{P_{t+1}} \frac{P_{t+1} + D_{t+1}}{P_t} \tag{A-7}$$

The equation for capital gains given in Equation (1.6) is equivalent to:

$$R_{t,t+n} = \frac{P_{t+n}}{P_t} + n\frac{D_t}{P_t} + \frac{D_t}{P_t} \sum_{m=0}^{n-1} \left(R_{t,t+n-1-m} \frac{P_{t+n}}{P_{t+n-m}} \frac{D_{t+n-m}/D_t}{P_{t+n-1-m}/P_t} - 1 \right) \tag{A-8}$$

I start by showing the equivalence of this equation to the one and two period cases, then derive the multiperiod case generally. In each case, I split out the terms relating to future dividends from the cumulative return product to isolate the capital gains, then algebraically manipulate the result to obtain the form in

Equation (A-8). The one period version of Equation (A-7) can be written as:

$$R_{t,t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} = \frac{P_{t+1}}{P_t} + \frac{D_t}{P_t} + \frac{D_{t+1} - D_t}{P_t} = \tag{A-9}$$

$$= \frac{P_{t+1}}{P_t} + \frac{D_t}{P_t} + \frac{D_t}{P_t}\left(\frac{P_{t+1}}{P_{t+1}}\frac{D_{t+1}/D_t}{P_t/P_t} - 1\right) \tag{A-10}$$

The first line separates out the dividend term then adds and subtracts D_t/P_t. To check the consistency of this result, the summation term of Equation (A-8) is, for $n = 1$:

$$\frac{D_t}{P_t}\sum_{m=0}^{n-1}\left(R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-m}}\frac{D_{t+n-m}/D_t}{P_{t+n-1-m}/P_t} - 1\right) = \frac{D_t}{P_t}\left(R_{t,t}\frac{P_{t+1}}{P_{t+1}}\frac{D_{t+1}/D_t}{P_t/P_t} - 1\right) \tag{A-11}$$

Which simplifies directly to the last term of Equation (A-10) for $R_{t,t} = 1$.

For two period returns the decomposition is, applying Equation (A-7):

$$R_{t,t+2} = \frac{P_{t+2} + D_{t+2}}{P_{t+1}}\frac{P_{t+1} + D_{t+1}}{P_t} = \frac{P_{t+2}}{P_t} + \frac{D_{t+2}}{P_{t+1}}R_{t,t+1} + \frac{P_{t+2}}{P_{t+1}}\frac{D_{t+1}}{P_t} = \tag{A-12}$$

$$= \frac{P_{t+2}}{P_t} + 2\frac{D_t}{P_t} + \frac{D_t}{P_t}\left(R_{t,t+1}\frac{D_{t+2}/D_t}{P_{t+1}/P_t} - 1\right) + \frac{D_t}{P_t}\left(\frac{P_{t+2}}{P_{t+1}}\frac{D_{t+1}/D_t}{P_t/P_t} - 1\right) \tag{A-13}$$

The first line separates out the two future dividend terms, and the second adds and subtracts D_t/P_t from both. To check this, the summation term of Equation (A-8) is, for $n = 2$:

$$\frac{D_t}{P_t}\sum_{m=0}^{n-1}\left(R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-m}}\frac{D_{t+n-m}/D_t}{P_{t+n-1-m}/P_t}-1\right)= \tag{A-14}$$

$$=\frac{D_t}{P_t}\left(R_{t,t+1}\frac{P_{t+2}}{P_{t+2}}\frac{D_{t+2}/D_t}{P_{t+1}/P_t}-1\right)+\frac{D_t}{P_t}\left(R_{t,t}\frac{P_{t+2}}{P_{t+1}}\frac{D_{t+1}/D_t}{P_t/P_t}-1\right) \tag{A-15}$$

Which again simplifies directly to the final two terms of Equation (A-13) for $R_{t,t}=1$.

Finally, I show the general result for n period returns. The approach is the same as for the one and two period cases; I split all the future dividend terms out of the cumulative return product to isolate the capital gains. Thus, to show the multiple period case, I split out the dividend from the first term of Equation (A-7) and substitute Equation (A-7) for $n-1$. For clarity, I place the dividend sum term that has been split from the cumulative return in square brackets [ ] and the next term to be removed in braces { }:

$$R_{t,t+n}=\left(\frac{P_{t+n}}{P_{t+n-1}}+\left\{\frac{D_{t+n}}{P_{t+n-1}}\right\}\right)\cdot\frac{P_{t+n-1}+D_{t+n-1}}{P_{t+n-2}}\cdot\ldots\cdot\frac{P_{t+2}+D_{t+2}}{P_{t+1}}\frac{P_{t+1}+D_{t+1}}{P_t} \tag{3}$$

$$R_{t,t+n}=\frac{P_{t+n}}{P_{t+n-1}}\cdot\left(\frac{P_{t+n-1}}{P_{t+n-2}}+\left\{\frac{D_{t+n-1}}{P_{t+n-2}}\right\}\right)\cdot\ldots\cdot\frac{P_{t+2}+D_{t+2}}{P_{t+1}}\frac{P_{t+1}+D_{t+1}}{P_t}+\left[\frac{D_{t+n}}{P_{t+n-1}}R_{t,t+n-1}\right] \tag{A-16}$$

Continue by splitting out the dividend terms one by one and substituting Equation (A-7) at each horizon:

$$R_{t,t+n}=\frac{P_{t+n}}{P_{t+n-2}}\cdot\left(\frac{P_{t+n-2}}{P_{t+n-3}}+\left\{\frac{D_{t+n-2}}{P_{t+n-3}}\right\}\right)\cdot\ldots\cdot\frac{P_{t+2}+D_{t+2}}{P_{t+1}}\frac{P_{t+1}+D_{t+1}}{P_t}+\left[\frac{D_{t+n}}{P_{t+n-1}}R_{t,t+n-1}+\frac{P_{t+n}}{P_{t+n-1}}\frac{D_{t+n-1}}{P_{t+n-2}}R_{t,t+n-2}\right] \tag{A-17}$$

$$\ldots$$

$$R_{t,t+n}=\frac{P_{t+n}}{P_{t+1}}\cdot\left(\frac{P_{t+1}}{P_t}+\left\{\frac{D_{t+1}}{P_t}\right\}\right)+\left[\frac{D_{t+n}}{P_{t+n-1}}R_{t,t+n-1}+\frac{P_{t+n}}{P_{t+n-1}}\frac{D_{t+n-1}}{P_{t+n-2}}R_{t,t+n-2}+\ldots+\frac{P_{t+n}}{P_{t+2}}\frac{D_{t+2}}{P_{t+1}}R_{t,t+1}\right] \tag{A-18}$$

$$R_{t,t+n} = \frac{P_{t+n}}{P_t} + \left[\frac{D_{t+n}}{P_{t+n-1}} R_{t,t+n-1} + \frac{P_{t+n}}{P_{t+n-1}} \frac{D_{t+n-1}}{P_{t+n-2}} R_{t,t+n-2} + ... + \frac{P_{t+n}}{P_{t+2}} \frac{D_{t+2}}{P_{t+1}} R_{t,t+1} + \frac{P_{t+n}}{P_{t+1}} \frac{D_{t+1}}{P_t}\right] \quad \text{(A-19)}$$

Adding and subtracting $n\frac{D_t}{P_t}$, grouping all terms involving future dividends into the summation, then dividing and multiplying each term in the sum by D_t/P_t delivers Equation (A-8):

$$\begin{aligned} R_{t,t+n} &= \frac{P_{t+n}}{P_t} + n\frac{D_t}{P_t} + \left[\frac{D_t}{P_t}\left(R_{t,t+n-1}\frac{D_{t+n}/D_t}{P_{t+n-1}/P_t} - 1\right) + \frac{D_t}{P_t}\left(R_{t,t+n-2}\frac{P_{t+n}}{P_{t+n-1}}\frac{D_{t+n-1}/D_t}{P_{t+n-2}/P_t} - 1\right) + ...\right. \\ &\left. ... + \frac{D_t}{P_t}\left(R_{t,t+1}\frac{P_{t+n}}{P_{t+2}}\frac{D_{t+2}/D_t}{P_{t+1}/P_t} - 1\right) + \frac{D_t}{P_t}\left(\frac{P_{t+n}}{P_{t+1}}\frac{D_{t+1}/D_t}{P_t/P_t} - 1\right)\right] \end{aligned} \quad \text{(A-20)}$$

$$R_{t,t+n} = \frac{P_{t+n}}{P_t} + n\frac{D_t}{P_t} + \left[\frac{D_t}{P_t}\sum_{m=0}^{n-1}\left(R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-m}}\frac{D_{t+n-m}/D_t}{P_{t+n-1-m}/P_t} - 1\right)\right] \quad (4)$$

Rearranging to place capital gains on the LHS of Equation (A-19) delivers the result, Equation (1.6):

$$\frac{P_{t+n}}{P_t} = -n\frac{D_t}{P_t} + R_{t,t+n} - \left[\frac{D_t}{P_t}\sum_{m=0}^{n-1}\left(R_{t,t+n-1-m}\frac{P_{t+n}}{P_{t+n-m}}\frac{D_{t+n-m}/D_t}{P_{t+n-1-m}/P_t} - 1\right)\right] \quad \text{(A-21)}$$

A.3 Affine Model Exposition

The solution method for strip prices in the model presented in Section 1.2.3 are as follows. First, let the demeaned vector of state variables of the model evolve as a SVVAR with multiple volatility processes scaling independent, multivariate standard normal shocks $\epsilon_{k,t+1}$, $k \in \{1, 2, ..., K\}$:

$$x_{t+1} = \Gamma x_t + \sum_{k=1}^{K} \sqrt{\sigma_{k,0} + \sigma_k x_t} \Sigma_k \epsilon_{k,t+1}$$

The stochastic discount factor follows the standard Epstein and Zin [27] form:

$$m_{t,t+1} = \theta log\beta - \frac{\theta}{\psi}\Delta c_{t+1} - (1-\theta) r^c_{t+1}$$

Consumption growth is an affine function of the states and shocks, as is dividend growth:

$$\Delta c_{t+1} = \mu_c + \delta_c x_t + \sum_{k=1}^{K} \sqrt{\sigma_{k,0} + \sigma_k x_t} \sigma_{c,k} \epsilon_{k,t+1}$$

$$\Delta d_{t+1} = \mu_d + \delta_d x_t + \sum_{k=1}^{K} \sqrt{\sigma_{k,0} + \sigma_k x_t} \sigma_{d,k} \epsilon_{k,t+1}$$

Finally, for simplicity I use the linearized asset return to solve for the parameters of the SDF in closed form by conjecturing the price to consumption ratio is given by $a + bx_t$:

$$r^c_{t+1} = ln(1+exp\{a\}) + \frac{exp\{a\}}{1+exp\{a\}} bx_{t+1} - a - bx_t + \mu_c + \delta_c x_t + \sum_{k=1}^{K} \sqrt{\sigma_{k,0} + \sigma_k x_t} \sigma_{c,k} \epsilon_{k,t+1}$$

Standard solution methods deliver the log stochastic discount factor:

$$m_{t,t+1} = -\lambda_0 - \lambda_x x_t - \sum_{k=1}^{K} \sqrt{\sigma_{k,0} + \sigma_k x_t}\lambda_k \epsilon_{k,t+1} - \sum_{k=1}^{K} \frac{1}{2}\lambda_k \lambda_k'(\sigma_{k,0} + \sigma_k x_t)$$

Thus the dividend prices and expected returns are given by a linear function of the states with $a_0 = 0$ and $b_0 = 0$:

$$pd_{n,t} = a_n + b_n x_t$$

The recursion for b_n shows how dividend beta accumulates over horizons to form strip beta based on the persistence of the states Γ and its covariance with the priced risks:

$$b_n = b_{n-1}\Gamma + \delta_d - \lambda_x + \sum_{k=1}^{K}(\frac{1}{2}b_{n-1}\Sigma_k\Sigma_k' b_{n-1}' + \delta_d\Sigma_k\Sigma_k' b_{n-1}' - \delta_d\Sigma_k\Sigma_k'\lambda_k' - b_{n-1}\Sigma_k\Sigma_k'\lambda_k')\sigma_{d,k} \tag{A-22}$$

This gives expected returns of:

$$E_t\Big[\frac{\Pi_{d,t+1}^{n-1}}{\Pi_{d,t}^{n}}\Big] = \exp\Big\{\lambda_0 + \sum_{k=1}^{K}\lambda_k(\sigma_{d,k} + b_{n-1}\Sigma_k)'\sigma_{k,0} + \Big[\lambda_x + \sum_{k=1}^{K}\lambda_k(\sigma_{d,k} + b_{n-1}\Sigma_k)'\sigma_k\Big]x_t\Big\} \tag{A-23}$$

The price of a 1 period riskfree bond is $-\lambda_0 - \lambda_x x_t = a_1^f + b_1^f x_t$ and the recursion for multi-period riskfree rates is standard for the affine pricing literature.

I use two states, conditional mean and volatility, and two shock sets $K = 2$, with one having state dependence (the consumption and dividend shocks and the conditional mean shock, impacted by stochastic volatility) and the other having only a mean (the volatility of volatility shock). The specific calibration I use, in the standard long run risks model notation for easy comparison with existing work, is, for the dividend and consumption dynamics, the persistence of expected consumption growth $\rho = .98$, the persistence of volatility $\nu = .98$, the mean of consumption and dividend growth $\mu_c = \mu_d = .02$, the exposure of conditional mean growth to the stochastic shock $\varphi_c = 0.44$, The unconditional mean of stochastic volatility $\sigma_0 = .0078$, the unconditional mean volatility of volatility $\sigma_w = .0000065$, the exposure of dividends to the conditional mean $\phi_d = 2.5$, the exposure of dividends to the consumption shock $\varsigma_d = 2.6$, and the exposure of dividends to the unpriced dividend shock $\varphi_d = 6$. For the preference parameters I use $\gamma = 13$, $\psi = 1.5$, and $\beta = .9989$.

A.4 Comparison to Alternative Cross-Sectional Methods

A core quantity in existing work using the cross-section to investigate the term structure of equity returns is the duration of the firm, the weighted average time of arrival of its cash flows. To show the difference between my approach and existing work that exploits between-firm, rather than within-firm, variation in risk premia I distinguish between the distribution of the value of the firm across the dividend strips of various horizons, the term distribution of firm value, and a firm's duration, a summary statistic for this quantity. The term distribution of firm value is:

$$w_{d,t}^{n} = \frac{\Pi_{d,t}^{n}}{\sum_{n=1}^{\infty} \Pi_{d,t}^{n}} = \frac{\Pi_{d,t}^{n}}{P_t} \quad \forall \quad n \in \{1, 2, ...\} \tag{A-24}$$

This is the portfolio weights in value terms of a dividend strip trading strategy that purchases the firm. This requires a transversality condition on the price in order to be well defined, which I assume holds throughout this exposition. I will refer to the mean in years of this distribution as the (true) firm duration:

$$Duration_t = \bar{w}_{d,t} = \sum_{n=1}^{\infty} n w_{d,t}^{n} \tag{A-25}$$

This is the object of interest in early cross-sectional approaches to the term structure, which estimate $\bar{w}_{d,t}$ by forecasting growth rates and making an assumption about returns by horizon. These studies then compare between-firm differences in returns and argue that low duration firms having high risk premia implies a downward sloping term structure of risk. Remember, the within-firm term structure of expected returns, $\{E_t[R^n_{d,t+1}]\}_{n\in\mathbb{N}}$, answers the question of what happens to the firm's discount rate if money is moved from the firm's projects which generate cash flows in the near future to those that generate cash flows in the distant future. This is the object of economic interest. To see this, we can rewrite the expected return on the firm as:

$$E_t[R_{t+1}] = \sum_{n=1}^{\infty} w^n_{d,t} E_t[R^n_{d,t+1}] \tag{A-26}$$

Which is just Equation (1.2) in the differing notation. The firm expected return is a weighted average of the strip expected returns where the weights are the term distribution of the firm's value. Changing the duration of the firm by taking fraction w of firm value from a typical project that delivers value solely at horizon n to a typical project that delivers value solely at $m \neq n$ changes the firm's expected return by $w(E_t[R^m_{d,t+1}] - E_t[R^n_{d,t+1}])$, assuming that the firm value remains unchanged. Finally, note that we can tautologically decompose $\Pi^n_{d,t}/D_t$ into:

$$\frac{\Pi^n_{d,t}}{D_t} = E_t\left[\frac{G_{t,t+n}}{R^n_{d,t,t+n}}\right] \tag{A-27}$$

Where $G_{t,t+n} = \frac{D_{t+n}}{D_t}$ s the cumulative firm dividend growth rate and $R^n_{d,t,t+n} = \frac{D_{t+n}}{\Pi^n_{d,t}}$ is the cumulative return on strip n. This establishes that the distribution of firm value across future payments contains firm and term specific risk and growth information. The approach proposed in section Section 1.2.2 implicitly accounts for both the firm specificity of risk and growth, by varying the regression coefficients across portfolios in the cross-section, and the term specificity of risk and growth by running the regression at multiple horizons. As demonstrated both in theory and in practice this replication can be done with high quality and a limited number of factors across firms and horizons, and regenerates the true term distribution of firm value in a theoretical environment where it is known. It remains to show the impact of applying alternative assumptions to obtain duration estimates.

The decomposition of the firm returns into strip returns in Equation (A-26) demonstrates that there are several types of variation captured by a comparison of firm returns. Such a comparison, e.g. $E_t[R_{i,t+1}] > E_t[R_{j,t+1}]$, holds if and only if:

$$\sum_{n=1}^{\infty} w_{i,t}^n E_t[R_{i,t+1}^n] > \sum_{n=1}^{\infty} w_{j,t}^n E_t[R_{j,t+1}^n] \tag{A-28}$$

All terms indexing firms, i or j, represent possible sources of variation leading to the difference in firm expected returns. Since Equation (A-27) shows that $w_{i,t}^n$ contains firm and term specific discount rate and growth information, a difference in firm expected returns could be driven by any of these sources of variation in addition to the average term structure slope. Explicitly, if both firms have the same amount of cash flow risk, i.e. $E_t[R_{i,t+1}^n] = E_t[R_{j,t+1}^n] \ \ \forall \ \ n \in \{1, 2, ...\}$, but there is a slope to the discount rate term structure, $E_t[R_{i,t+1}^n] \neq E_t[R_{i,t+1}^{n+1}]$ for some n, then Equation (A-28) holds when i delivers more of its value at high discount rate horizons because its cumulative growth is higher at those times. If firms differ in their amount of cash flow risk but have the same distribution of value, Equation (A-28) holds when i has more cash flow risk on average than j. Thus a difference in cash flow risk between i and j breaks the identification of the term structure from between-firm variation in the cross section, regardless of the assumptions used to estimate the terms in Equation (A-25). Tables 1.10 and 1.11 provide evidence that there is a difference in cash flow risk between growth and value firms directly, since the cumulative dividend claim term structures do not overlap and are generally higher for riskier firms. This is consistent with models driven by dividend risk differences in the cross section, but inconsistent with between firm risk premium differences identifying the term structure.

A stylized numerical example will make the intuition concrete. There are two firms, i and j, and two dates, 1 and 2. Firm i is expected to grow at rate 5% to both dates, firm j at 10% to date 1 then 0% to date 2. Both have upward sloping term structures but firm j has more cash flow risk so that $E[R^1_{i,t+1}] = 5\%$ and $E[R^2_{i,t+1}] = 6\%$, but $E[R^1_{j,t+1}] = 15\%$, and $E[R^2_{j,t+1}] = 18\%$. Assuming no updating between periods and that these are the correct discount rates for the firms' expected growth we can simply apply Equation (A-27) to determine the firm distributions of value. Firm j has lower duration (54% vs 50% in claim 1) and higher mean returns. The same is true if the discount rate is assumed to be, counterfactually, shared and flat at 5% (51% vs 50% in claim 1). The essential component here is that one firm has high discount rates and high expected near term growth - this is the evidence on the value sorted buy-and-hold cross-section in Chen [21]. The implication is that the between-firm difference in growth rates, and therefore duration, does not mean the between-firm difference in discount rates identifies the term structure of either firm or of both firms on average. Only the case where the true discount rate is shared across horizons guarantees identification of the within-firm term structure by between-firm differences in risk premia.

Evidence based on between firm discount rate differences can only identify within-firm term structure variation by assuming other types of variation do not exist[2]. Recall from equation Equation (A-22) that the core mechanisms generating cross-sectional differences in risk premia in typical general equilibrium cross-sectional pricing theory, differences in dividend beta to priced states, imply differences in cash flow strip beta at every horizon, not just overall. In order to falsify these theories with between-firm differences in risk premia we must assume their core mechanism does not hold in practice in order to provide identification.

[2]For example, Weber [59] uses a constant, flat, shared discount rate assumption for all firms and terms, while Lettau and Wachter [46] assumes a constant, sloping, shared discount rate assumption. Under these assumptions, differences in firm returns are sufficient to identify the slope of the discount rate curve. Weber [59] argues that he identifies duration as an unspanned cross-sectional factor, so this analysis only critiques the interpretation that his evidence supports within-firm term structure conclusions.

Table A.1: Term Structures of Excess Returns - Value Sorted Cross-Section

		Buy and Hold				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	6.83%	$7.05\%^{*}$	$7.38\%^{***}_{***}$	$7.68\%^{***}_{***}$	$8.18\%^{***}_{***}$	$8.99\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	6.05%	6.20%	$6.42\%^{**}_{***}$	$6.58\%^{*}_{**}$	$6.81\%^{*}_{**}$	$7.38\%^{**}_{**}$
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	7.60%	7.85%	$8.25\%^{***}_{***}$	$8.50\%^{***}_{***}$	$8.86\%^{**}_{***}$	$9.38\%^{***}_{***}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	10.83%	$11.26\%^{***}$	$11.78\%^{***}_{***}$	$12.28\%^{***}_{***}$	$12.88\%^{***}_{***}$	$13.49\%^{***}_{***}$
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.82\%^{***}$	$-1.45\%^{***}_{**}$	$-0.33\%^{***}$	$-0.24\%^{***}$	$-0.71\%^{***}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.19\%^{***}$	$-0.30\%^{***}_{*}$	$1.28\%^{***}$	$1.60\%^{***}$	$1.19\%^{**}$
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-3.45\%^{***}$	$-0.73\%^{***}_{***}$	$1.20\%^{***}_{***}$	$2.13\%^{***}_{**}$	$1.60\%^{***}_{***}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-4.71\%^{***}$	$-0.45\%^{***}_{***}$	$1.94\%^{***}_{***}$	$3.00\%^{***}_{**}$	$2.25\%^{***}_{**}$
		Rebalanced				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	6.61%	$6.82\%^{*}$	$7.13\%^{***}_{***}$	$7.45\%^{***}_{***}$	$7.88\%^{***}_{***}$	$8.56\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	6.50%	6.63%	6.71%	6.79%	$7.23\%^{*}_{**}$	$7.73\%^{*}_{*}$
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	7.55%	$7.83\%^{*}$	$8.10\%^{***}_{***}$	$8.58\%^{**}_{**}$	$9.07\%^{*}_{*}$	$9.21\%^{*}_{*}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	11.13%	$11.63\%^{***}$	$12.23\%^{***}_{***}$	$12.38\%^{**}_{*}$	12.20%	12.61%
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-3.19\%^{***}$	$-1.63\%^{***}_{***}$	$-0.55\%^{***}$	$-0.17\%^{***}$	$-0.40\%^{***}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.82\%^{***}$	$0.46\%^{***}_{***}$	$1.86\%^{**}_{***}$	$0.90\%^{***}$	$0.57\%^{*}$
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.69\%^{***}$	$-0.45\%^{***}_{***}$	$0.61\%^{***}$	$1.25\%^{**}$	$2.49\%_{**}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.41\%^{***}$	$1.04\%^{***}_{***}$	$5.80\%^{*}_{**}$	$7.51\%_{*}$	8.12%

Notes: The sort is based on the most recent book equity to market equity ratio for the firm. Portfolio vintages are formed monthly based on 6 month lagged accounting data but are otherwise formed as in Fama and French [28] for buy-and-hold portfolios. For rebalanced portfolios the data is as in Fama and French [28]. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2, 5 , and 9 portfolios. I present significant differences from the asset excess return as superscript stars (*** for significance at the 1% level, ** at 5%, and * at 10%), and significant differences from the horizon 1 excess returns as subscript stars.

A.5 Alternative Sorts and Results

In this appendix I present the results of the pricing and return computation experiments for buy-and-hold and rebalanced portfolios based on alternative cross-sectional sorts. These sorts demonstrate the flexibility of my method in expanding the scope of term structure data while also confirming the consistency of my core conclusions across various cross-sections. I present only the return regressions with their significance estimates for brevity, but can provide the replicating regression outputs on request.

Table A.2: Term Structures of Excess Returns - Size Sorted Cross-Section

		Buy and Hold				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	6.83%	$7.05\%^{*}$	$7.38\%^{***}_{***}$	$7.68\%^{***}_{***}$	$8.18\%^{***}_{***}$	$8.99\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	11.34%	11.64%	$12.17\%^{**}_{***}$	$12.86\%^{**}_{***}$	$13.42\%^{**}_{**}$	12.40%
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	9.31%	9.60%	$9.96\%^{**}_{***}$	$10.31\%^{**}_{**}$	$10.30\%^{**}_{***}$	$10.49\%^{***}_{***}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	8.29%	$8.52\%^{*}$	$8.86\%^{***}_{***}$	$9.28\%^{***}_{***}$	$9.80\%^{***}_{***}$	$10.42\%^{***}_{***}$
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.82\%^{***}$	$-1.45\%^{***}_{**}$	$-0.33\%^{***}$	$-0.24\%^{***}$	$-0.71\%^{***}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.57\%^{***}$	$-0.32\%^{***}$	2.84%	8.76%	$7.93\%_{***}$
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-5.26\%^{***}$	$-1.48\%^{***}_{***}$	$1.56\%^{***}_{***}$	$2.74\%^{***}_{***}$	$2.36\%^{***}_{***}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-4.83\%^{***}$	$-2.83\%^{***}_{**}$	$-1.57\%^{***}_{*}$	$-1.03\%^{***}$	$-0.96\%^{***}$
		Rebalanced				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	6.61%	$6.82\%^{*}$	$7.13\%^{***}_{***}$	$7.45\%^{***}_{***}$	$7.88\%^{***}_{***}$	$8.56\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	9.54%	9.80%	$10.20\%^{*}_{**}$	10.12%	$9.94\%^{*}$	10.32%
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	9.48%	9.75%	$10.13\%^{**}_{***}$	$10.39\%^{*}_{*}$	$10.43\%^{*}_{*}$	$10.65\%^{*}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	7.57%	$7.81\%^{**}$	$8.16\%^{***}_{***}$	$8.58\%^{***}_{***}$	$8.91\%^{***}_{***}$	$9.39\%^{***}_{***}$
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-3.19\%^{***}$	$-1.63\%^{***}_{***}$	$-0.55\%^{***}$	$-0.17\%^{***}$	$-0.40\%^{***}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.76\%^{***}$	$0.40\%^{**}$	$3.98\%_{**}$	$5.46\%^{***}_{***}$	$4.70\%_{*}$
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-4.35\%^{***}$	$-1.85\%^{***}_{*}$	$1.53\%^{**}$	$3.17\%^{**}_{***}$	$2.87\%^{**}_{**}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-3.16\%^{***}$	$-1.67\%^{***}_{**}$	$-0.55\%^{***}$	$0.39\%^{***}$	$0.57\%^{***}_{**}$

Notes: The sort is based on the most recent market equity capitalization value of the firm's primary security. Portfolio vintages are formed monthly based on 6 month lagged accounting data but are otherwise formed as in Fama and French [28] for buy-and-hold portfolios. For rebalanced portfolios the data is as in Fama and French [28]. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2, 5 , and 9 portfolios. I present significant differences from the asset excess return as superscript stars (*** for significance at the 1% level, ** at 5%, and * at 10%), and significant differences from the horizon 1 excess returns as subscript stars.

Table A.3: Term Structures of Excess Returns - Gross Profitability Sorted Cross-Section

		Buy and Hold				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	5.21%	5.36%	$5.61\%^{**}_{**}$	$5.72\%^{***}_{***}$	$5.95\%^{***}_{***}$	$6.48\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	3.94%	4.04%	$4.20\%_{***}$	$4.36\%_{**}$	4.54%	$5.09\%^{***}_{***}$
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	5.69%	5.82%	$6.03\%^{**}_{***}$	$6.07\%^{*}_{**}$	6.23%	$6.42\%^{**}_{**}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	7.19%	7.31%	$7.61\%^{**}_{*}$	$7.73\%^{**}$	$7.93\%^{**}_{*}$	$8.38\%^{**}_{*}$
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.14\%^{*}$	$-1.21\%^{*}_{***}$	$0.31\%^{*}$	$0.78\%^{*}$	0.43%
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−1.06%	−0.23%	$0.49\%^{*}$	$0.63\%^{*}$	0.34%
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-1.16\%^{*}$	$0.65\%_{*}$	2.76%	$3.36\%^{*}$	3.87%
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−1.17%	−0.35%	$2.34\%_{***}$	$3.18\%_{***}$	$3.01\%_{***}$
		Rebalanced				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	4.92%	5.06%	$5.28\%^{**}_{**}$	$5.39\%^{***}_{***}$	$5.55\%^{**}_{**}$	$5.95\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	3.68%	3.84%	$4.09\%^{**}_{***}$	$4.32\%^{***}_{***}$	$4.71\%^{***}_{***}$	$5.26\%^{***}_{***}$
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	5.87%	6.04%	$6.36\%^{*}_{**}$	$6.67\%^{***}_{***}$	6.60%	6.88%
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	7.23%	7.40%	$7.74\%^{***}_{***}$	$7.67\%^{*}_{*}$	7.73%	$8.03\%^{*}$
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.52\%^{*}$	$-1.30\%^{*}_{***}$	$0.22\%^{**}$	$0.93\%^{*}$	$0.85\%_{*}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		−1.23%	−1.62%	−0.80%	0.34%	1.71%
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-1.59\%^{*}$	$-0.27\%^{**}$	$1.27\%^{***}$	2.98%	3.95%
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-1.96\%^{*}$	$-1.26\%^{*}$	$2.54\%^{**}$	3.49%	2.95%

Notes: The sort is based on the most recent observation of the firm's gross profitability to book equity ratio. Portfolio vintages are formed monthly based on 6 month lagged accounting data but are otherwise formed as in Fama and French [29] for buy-and-hold portfolios. For rebalanced portfolios the data is as in Fama and French [29]. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1966 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2, 5 , and 9 portfolios. I present significant differences from the asset excess return as superscript stars (*** for significance at the 1% level, ** at 5%, and * at 10%), and significant differences from the horizon 1 excess returns as subscript stars.

Table A.4: Term Structures of Excess Returns - Asset Growth Sorted Cross-Section

		Buy and Hold				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	5.21%	5.36%	$5.61\%^{**}_{**}$	$5.72\%^{***}_{***}$	$5.95\%^{***}_{***}$	$6.48\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	8.70%	8.90%	$9.19\%^{*}_{***}$	$9.49\%^{**}_{***}$	$9.87\%^{**}_{**}$	10.45%
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	5.99%	6.14%	$6.39\%^{*}$	$6.56\%^{*}$	$6.81\%^{**}_{**}$	$7.19\%^{*}_{**}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	4.59%	4.64%	4.73%	4.79%	4.97%	5.21%
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.14\%^{*}$	$-1.21\%^{*}_{***}$	$0.31\%^{*}$	$0.78\%^{*}$	0.43%
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-5.80\%^{***}$	$-1.66\%^{***}_{***}$	$0.88\%^{**}_{***}$	$1.36\%^{**}_{***}$	$2.40\%_{*}$
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-1.11\%^{**}$	$0.63\%_{***}$	$2.01\%_{***}$	$2.86\%_{***}$	$3.13\%_{**}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		-2.12%	$1.17\%_{*}$	2.94%	3.15%	3.93%
		Rebalanced				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	4.92%	5.06%	$5.28\%^{**}_{**}$	$5.39\%^{***}_{***}$	$5.55\%^{**}_{**}$	$5.95\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	8.96%	9.15%	9.44%	9.41%	9.81%	10.11%
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	6.15%	6.35%	$6.60\%^{*}$	$6.79\%^{**}_{**}$	$7.26\%^{***}_{**}$	$7.56\%^{*}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	4.80%	4.88%	$5.06\%_{**}$	$5.15\%^{*}_{**}$	$5.28\%^{**}_{*}$	$5.44\%^{**}_{**}$
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-2.52\%^{*}$	$-1.30\%^{*}_{***}$	$0.22\%^{**}$	$0.93\%^{*}$	$0.85\%_{*}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-1.92\%^{***}$	$1.73\%^{*}$	$5.07\%_{*}$	3.87%	5.40%
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		$-3.28\%^{**}$	$-0.69\%^{*}_{***}$	$1.12\%^{**}_{*}$	$0.93\%^{***}$	$1.57\%^{*}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$		-2.34%	$0.46\%_{***}$	$1.05\%_{**}$	$1.87\%_{*}$	$2.80\%_{**}$

Notes: The sort is based on the most recent observation of the firm's annual asset growth. Portfolio vintages are formed monthly based on 6 month lagged accounting data but are otherwise formed as in Fama and French [29] for buy-and-hold portfolios. For rebalanced portfolios the data is as in Fama and French [29]. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1966 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2, 5 , and 9 portfolios. I present significant differences from the asset excess return as superscript stars (*** for significance at the 1% level, ** at 5%, and * at 10%), and significant differences from the horizon 1 excess returns as subscript stars.

Table A.5: Term Structures of Excess Returns - Momentum Sorted Cross-Section

		Buy and Hold				
	Asset	Claim Horizon				
		1	2	3	4	5
Market $E[R^n_{p,1} - R^1_{f,0}]$	6.83%	$7.05\%^{*}$	$7.38\%^{***}_{***}$	$7.68\%^{***}_{***}$	$8.18\%^{***}_{***}$	$8.99\%^{***}_{***}$
Portfolio 2 $E[R^n_{p,1} - R^1_{f,0}]$	5.45%	$5.69\%^{*}$	$6.13\%^{***}_{***}$	$6.41\%^{***}_{***}$	$6.72\%^{**}_{**}$	$7.98\%^{**}_{**}$
Portfolio 5 $E[R^n_{p,1} - R^1_{f,0}]$	7.33%	$7.55\%^{*}$	$7.91\%^{***}_{***}$	$8.28\%^{***}_{***}$	$8.80\%^{***}_{***}$	$9.72\%^{***}_{***}$
Portfolio 9 $E[R^n_{p,1} - R^1_{f,0}]$	8.81%	9.00%	$9.29\%^{**}_{***}$	$9.55\%^{*}_{**}$	9.67%	10.14%
Market $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	6.83%	$-2.82\%^{***}$	$-1.45\%^{***}_{**}$	$-0.33\%^{***}$	$-0.24\%^{***}$	$-0.71\%^{***}$
Portfolio 2 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	5.45%	$-8.38\%^{***}$	$-4.40\%^{***}_{**}$	$-0.90\%^{***}_{*}$	$-0.03\%^{**}$	-0.99%
Portfolio 5 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	7.33%	$-2.11\%^{***}$	$-0.61\%^{**}$	$0.94\%^{**}_{**}$	$1.59\%^{***}_{*}$	$1.10\%^{***}$
Portfolio 9 $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	8.81%	$2.19\%^{***}$	$5.47\%_{*}$	6.65%	7.49%	7.44%

Notes: The sort is based on the most recent observation of the firm's 11 month prior to two month prior return. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2, 5 , and 9 portfolios. I present significant differences from the asset excess return as superscript stars (*** for significance at the 1% level, ** at 5%, and * at 10%), and significant differences from the horizon 1 excess returns as subscript stars.

Table A.6: Term Structures of Continuation Excess Returns - International

		Rebalanced				
	Asset	Continuation Claim Horizon				
		1	2	3	4	5
EU $E[R^n_{p,1} - R^1_{f,0}]$	7.73%	7.90%	8.12%	8.19%	8.58%	9.13%
Europe $E[R^n_{p,1} - R^1_{f,0}]$	7.94%	8.12%	8.34%	8.44%	8.84%	9.40%
Japan $E[R^n_{p,1} - R^1_{f,0}]$	5.88%	5.94%	6.04%	6.12%	6.25%	6.35%
UK $E[R^n_{p,1} - R^1_{f,0}]$	8.65%	8.89%	9.10%	9.25%	9.46%	10.11%
US $E[R^n_{p,1} - R^1_{f,0}]$	6.71%	6.93%	7.31%	7.70%	8.18%	8.79%
World $E[R^n_{p,1} - R^1_{f,0}]$	6.54%	6.72%	6.98%	7.17%	7.56%	8.06%

Notes: All international indices are US dollar returns to the relevant Datastream/Thompson Reuters Index. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1974 to 6/2012 to compute both the regression coefficients and the mean excess returns.

Table A.7: Term Structures of Dividend Excess Returns - International

		Rebalanced				
	Asset	Cumulative Dividend Claim Horizon				
		1	2	3	4	5
EU $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	7.73%	−1.73%	0.71%	2.74%	2.32%	2.05%
Europe $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	7.94%	−1.83%	0.69%	2.61%	2.27%	2.06%
Japan $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	5.88%	−1.89%	0.44%	1.85%	2.65%	2.55%
UK $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	8.65%	−2.20%	1.18%	3.06%	3.59%	2.88%
US $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	6.71%	−4.14%	−3.37%	−2.24%	−1.81%	−1.42%
World $E[\bar{R}^n_{d,1} - R^1_{f,0}]$	6.54%	−3.23%	−1.36%	0.40%	0.66%	0.62%

Notes: All international indices are US dollar returns to the relevant Datastream/Thompson Reuters Index. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1974 to 6/2012 to compute both the regression coefficients and the mean excess returns.

Table A.8: Term Structures of Sharpe Ratios - U.S. Market

		Rebalanced				
	Asset	Claim Horizon				
		1	2	3	4	5
		Continuation Claims				
Market $SR^n_{p,1}$	0.384	0.392	0.399	0.405	0.415	0.432
Market $SR^n_{p,1} - SR_{M,1}$		0.008	0.016	0.021	0.031	0.048
Model Median $SR^n_{p,1} - SR_{M,1}$		0.007	0.013	0.019	0.024	0.030
		Cumulative Dividend Claims				
Market $SR^n_{d,1}$		-0.180	-0.091	-0.031	-0.009	-0.022
Market $SR^n_{d,1} - SR_{M,1}$		-0.564	-0.475	-0.414	-0.393	-0.406
Model Median $SR^n_{d,1} - SR_{M,1}$		-0.546	-0.514	-0.480	-0.446	-0.416

Notes: The sort is based on the most recent book equity to market equity ratio for the firm. Portfolio vintages are formed monthly based on 6 month lagged accounting data but are otherwise formed as in Fama and French [28] for buy-and-hold portfolios. For rebalanced portfolios the data is as in Fama and French [28]. I present the mean excess returns of the asset and the estimated excess returns of the continuation and cumulative dividend claims. The continuation claim returns are given by $\hat{R}^n_{p,1} = \frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}}$ and the dividend claim returns by $\hat{\bar{R}}^n_{d,1} = \frac{1}{1-\hat{\Pi}^n_{p,0}}(R_1 - \hat{\Pi}^n_{p,0}\frac{\hat{\Pi}^{n-1}_{p,1}}{\hat{\Pi}^n_{p,0}})$. I use monthly formation dates from 6/1950 to 6/2012 to compute both the regression coefficients and the mean excess returns, and present the results for the decile 2, 5 , and 9 portfolios. The statistics presented are the Sharpe Ratio of the claim: $SR^n_{p,1} = \frac{\hat{R}^n_{p,1} - R^1_{f,0}}{\sigma_{\hat{R}^n_{p,1}}}$ or $SR^n_{d,1} = \frac{\bar{R}^n_{d,1} - R^1_{f,0}}{\sigma_{\bar{R}^n_{d,1}}}$, where $SR_{M,1} = \frac{R_{M,1} - R^1_{f,0}}{\sigma_{\bar{R}_{M,1}}}$ is the asset Sharpe Ratio. I also present the median of the Sharpe Ratio differences produced by the model described in Section 1.2.3.

A.6 Bayesian Linear Regression

Without loss of generality, we can express any linear dynamics by

$$y_t = \Phi x_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma). \tag{A-29}$$

For ease of exposition, define $Y = [y_p, ..., y_T]'$, $X = [x_p, ..., x_T]'$, and $\varepsilon = [\varepsilon_p, ..., \varepsilon_T]'$. Assume that the initial p observations are available. Because of the conjugacy if the prior is

$$\Phi|\Sigma \sim MN\big(\underline{\Phi}, \Sigma \otimes (\underline{V}_\Phi \xi)\big), \quad \Sigma \sim IW(\Psi, d) \tag{A-30}$$

then the posterior can be expressed as $\Phi|\Sigma \sim MN\big(\overline{\Phi}, \Sigma \otimes \overline{V}_\Phi\big)$ where

$$\overline{\Phi} \;=\; \Big(X'X + (\underline{V}_\Phi \xi)^{-1}\Big)^{-1}\Big(X'Y + (\underline{V}_\Phi \xi)^{-1}\underline{\Phi}\Big), \quad \overline{V}_\Phi = \Big(X'X + (\underline{V}_\Phi \xi)^{-1}\Big)^{-1}.$$

We follow the exposition in [31]. ξ is a scalar parameter controlling the tightness of the prior information. For instance, prior becomes more informative when $\xi \to 0$. In contrast, when $\xi = \infty$, then it is easy to see that $\overline{\Phi} = \hat{\Phi}$, i.e., an OLS estimate. We can choose ξ that maximizes the marginal likelihood function (A-31), which is available in closed form

$$\begin{aligned} p(Y|\xi) \;=\; & \left(\frac{1}{\pi}\right)^{\frac{n(T-p)}{2}} \frac{\Gamma_n\big(\frac{T-p+d}{2}\big)}{\Gamma_n\big(\frac{d}{2}\big)} |\underline{V}_\Phi \xi|^{-\frac{n}{2}} |\Psi|^{\frac{d}{2}} \Big|X'X + (\underline{V}_\Phi \xi)^{-1}\Big|^{-\frac{n}{2}} \\ & \Big|\Psi + \hat{\varepsilon}'\hat{\varepsilon} + (\hat{\Phi} - \underline{\Phi})'(\underline{V}_\Phi \xi)^{-1}(\hat{\Phi} - \underline{\Phi})\Big|^{-\frac{T-p+d}{2}}. \end{aligned} \tag{A-31}$$

We refer to [31] for a detailed description.

A.7 Solving the Regime-Switching Model

This section provides approximate analytical solutions for the asset prices.

A.7.1 Exogenous Dynamics

The joint dynamics of consumption and dividend growth are

$$\begin{aligned}
\Delta c_{t+1} &= \mu(S_{t+1}) + x_{t+1} + \sigma_c \eta_{c,t+1}, \quad \eta_{c,t+1} \sim N(0,1), \qquad \text{(A-32)} \\
\Delta d_{t+1} &= \bar{\mu} + \phi(\Delta c_{t+1} - \bar{\mu}) + \sigma_d \eta_{d,t+1}, \quad \eta_{d,t+1} \sim N(0,1), \\
x_{t+1} &= \rho x_t + \sigma_x(S_{t+1})\epsilon_{t+1},
\end{aligned}$$

where $\bar{\mu}$ is the unconditional mean of consumption growth and x_t is the persistent component of consumption growth. Agents observe the current regime, S_t, and make forecast of future regime, S_{t+1}, based on the transition matrix below

$$\mathbb{P} = \begin{bmatrix} p_1 & 1-p_1 \\ 1-p_2 & p_2 \end{bmatrix}. \qquad \text{(A-33)}$$

A.7.2 Stochastic Discount Factor

Assume that the log stochastic discount factor is

$$m_{t+1} = -r_{t+1} - \frac{1}{2}\lambda(S_{t+1})^2 - \lambda(S_{t+1})\epsilon_{t+1}. \qquad \text{(A-34)}$$

The risk-free rate is exogenously defined by $r_{t+1} = r_0(S_{t+1}) + r_1(S_{t+1})x_{t+1}$. We assume that the market price of risk is $\lambda_{t+1} = \lambda(S_{t+1})$.

A.7.3 Real Bond Prices

Conjecture that $b_{n,t}$ depends on the regime S_t and x_t,

$$b_{n,t} = b_{n,0}(S_t) + b_{n,1}(S_t)x_t. \tag{A-35}$$

Exploit the law of iterated expectations

$$b_{n,t} \;\; = \;\; \ln E_t\bigg(E[\exp(m_{t+1} + b_{n-1,t+1})|S_{t+1}]\bigg)$$

and log-linearization to solve for $b_{n,t}$

$$b_{n,t} \;\; \approx \;\; \sum_{j=1}^{2} \mathbb{P}_{ij}\bigg(E[m_{t+1} + b_{n-1,t+1}|S_{t+1}] + \frac{1}{2}Var[m_{t+1} + b_{n-1,t+1}|S_{t+1}]\bigg).$$

The solution to (A-35) is

$$\begin{bmatrix} b_{n,0}(1) \\ b_{n,0}(2) \end{bmatrix} = \mathbb{P} \times \begin{bmatrix} b_{n-1,0}(1) - r_0(1) + 0.5(b_{n-1,1}(1) - r_1(1))^2\sigma_x(1)^2 - (b_{n-1,1}(1) - r_1(1))\sigma_x(1)\lambda(1) \\ b_{n-1,0}(2) - r_0(2) + 0.5(b_{n-1,1}(2) - r_1(2))^2\sigma_x(2)^2 - (b_{n-1,1}(2) - r_1(2))\sigma_x(2)\lambda(2) \end{bmatrix} \tag{A-36}$$

$$\begin{bmatrix} b_{n,1}(1) \\ b_{n,1}(2) \end{bmatrix} = \mathbb{P} \times \begin{bmatrix} (b_{n-1,1}(1) - r_1(1))\rho \\ (b_{n-1,1}(1) - r_1(1))\rho \end{bmatrix}$$

with the initial condition $b_{0,0}(i) = 0$ and $b_{0,1}(i) = 0$ for $i \in \{1, 2\}$. The real yield of the maturity n-period bond is $y^r_{n,t} = -\frac{1}{n}b_{n,t}$.

A.7.4 Price to Dividend Ratio of Zero Coupon Equity

Conjecture that the log price to dividend ratio of zero coupon equity $z_{n,t}$ depends on the regime S_t and persistent component x_t,

$$z_{n,t} = z_{n,0}(S_t) + z_{n,1}(S_t)x_t. \tag{A-37}$$

Exploit the law of iterated expectations

$$Z_{n,t} = E_t\Big(E[M_{t+1}Z_{n-1,t+1}\frac{D_{t+1}}{D_t}|S_{t+1}]\Big)$$

Take log

$$z_{n,t} = \ln E_t\Big(E[\exp(m_{t+1} + z_{n-1,t+1} + \Delta d_{t+1})|S_{t+1}]\Big)$$

and log-linearization to solve for $z_{n,t}$

$$z_{n,t} \approx \sum_{j=1}^{2}\mathbb{P}_{ij}\Big(E[\exp(m_{t+1} + z_{n-1,t+1} + \Delta d_{t+1})|S_{t+1}] + \frac{1}{2}Var[\exp(m_{t+1} + z_{n-1,t+1} + \Delta d_{t+1})|S_{t+1}]\Big).$$

The solution is

$$\begin{bmatrix} z_{n,0}(1) \\ z_{n,0}(2) \end{bmatrix} = \begin{bmatrix} (1-\phi)\bar{\mu} + \frac{\phi^2}{2}\sigma_c^2 + \frac{1}{2}\sigma_d^2 \\ (1-\phi)\bar{\mu} + \frac{\phi^2}{2}\sigma_c^2 + \frac{1}{2}\sigma_d^2 \end{bmatrix} + \mathbb{P} \times \begin{bmatrix} z_{n-1,0}(1) + \phi\mu(1) - r_0(1) + \Xi(1) \\ z_{n-1,0}(2) + \phi\mu(2) - r_0(2) + \Xi(2) \end{bmatrix} \tag{A-38}$$

$$\Xi(j) = \frac{1}{2}\big(z_{n-1,1}(j) - r_1(j) + \phi\big)^2\sigma_x(j)^2 - \big(z_{n-1,1}(j) - r_1(j) + \phi\big)\sigma_x(j)\lambda(j)$$

$$\begin{bmatrix} z_{n,1}(1) \\ z_{n,1}(2) \end{bmatrix} = \mathbb{P} \times \begin{bmatrix} \big(z_{n-1,1}(1) - r_1(1) + \phi\big)\rho \\ \big(z_{n-1,1}(1) - r_1(1) + \phi\big)\rho \end{bmatrix}. \tag{A-39}$$

The initial condition is $z_{0,0}(i) = 0$ and $z_{0,1}(i) = 0$ for $i \in \{1, 2\}$.

A.7.5 m-Holding-Period and Hold-to-Maturity Expected Returns

The price of zero coupon equity is $P_{n,t} = Z_{n,t}D_t$. Define the m-holding period return of the n-maturity equity is

$$R_{n,t+m} = \frac{Z_{n-m,t+m}}{Z_{n,t}}\frac{D_{t+m}}{D_t}. \tag{A-40}$$

The corresponding log expected return is defined by

$$E_t[r_{n,t+m}] = \frac{1}{m} E_t\big(z_{n-m,t+m} - z_{n,t} + \sum_{i=1}^{m} \Delta d_{t+i}\big) \tag{A-41}$$

To compute the excess return, we subtract the real rate of the same maturity

$$E_t[r_{n,t+m}] - y^r_{m,t}. \tag{A-42}$$

We consider two cases

- $m \neq n$: This is the m-holding-period expected excess return of the n maturity equity.

$$\begin{aligned} E_t[g_{d,t+m}] &= \frac{1}{m} E_t\big(\sum_{i=1}^{m} \Delta d_{t+i}\big) \\ e_{n,m,t} &= \frac{1}{m} E_t\big(z_{n-m,t+m} - z_{n,t}\big) \\ E_t[r_{n,t+m}] &= e_{n,m,t} + E_t[g_{d,t+m}] \\ E_t[rx_{n,t+m}] &= E_t[r_{n,t+m}] - y^r_{m,t}. \end{aligned} \tag{A-43}$$

- $m = n$: This is the hold-to-maturity expected excess return of the n maturity equity. Define

$$\begin{aligned} E_t[g_{d,t+n}] &= \frac{1}{n} E_t\big(\sum_{i=1}^{n} \Delta d_{t+i}\big) \\ e_{n,t} &= \frac{1}{n} E_t\big(- z_{n,t}\big) \\ E_t[r_{t+n}] &= e_{n,t} + E_t[g_{d,t+n}] \\ E_t[rx_{t+n}] &= E_t[r_{t+n}] - y^r_{n,t}. \end{aligned} \tag{A-44}$$

A.7.6 Computing Moments

The cumulative sum of log dividend growth rates are

$$\sum_{i=1}^{n} \Delta d_{t+i} = n(1-\phi)\bar{\mu} + \phi\big(\mu(S_{t+1}) + ... + \mu(S_{t+n})\big) + \phi\rho\left(\frac{1-\rho^n}{1-\rho}\right)x_t \quad \text{(A-45)}$$
$$+ \phi\left(\frac{1-\rho^n}{1-\rho}\right)\sigma_x(S_{t+1})\epsilon_{t+1} + ... + \phi\left(\frac{1-\rho}{1-\rho}\right)\sigma_x(S_{t+n})\epsilon_{t+n}$$
$$+ \phi\sigma_c(\eta_{c,t+1} + ... + \eta_{c,t+n}) + \sigma_d(\eta_{d,t+1} + ... + \eta_{d,t+n}).$$

For ease of exposition, we introduce the following notations

$$\boldsymbol{\mu} = [\mu(1), \mu(2)]', \quad \boldsymbol{\sigma_x^2} = [\sigma_x(1)^2, \sigma_x(2)^2]'.$$

Similarly, define

$$\boldsymbol{\mu_G} = [\mu_G(1), \mu_G(2)]', \quad \boldsymbol{\sigma_G^2} = [\sigma_G(1)^2, \sigma_G(2)^2]'.$$

The first two moments of the average log dividend growth rates are

$$E_t[g_{d,t+n}] = \frac{1}{n}E_t[\sum_{i=1}^{n} \Delta d_{t+i}] = \frac{1}{n}\mu_G \quad \text{(A-46)}$$
$$V_t[g_{d,t+n}] = \frac{1}{n^2}V_t[\sum_{i=1}^{n} \Delta d_{t+i}] = \frac{1}{n^2}\sigma_G^2$$

where

$$\boldsymbol{\mu_G} = \begin{bmatrix} n(1-\phi)\bar{\mu} + \phi\rho\left(\frac{1-\rho^n}{1-\rho}\right)x_t \\ n(1-\phi)\bar{\mu} + \phi\rho\left(\frac{1-\rho^n}{1-\rho}\right)x_t \end{bmatrix} + \sum_{j=1}^{n} \phi \mathbb{P}^j \boldsymbol{\mu} \tag{A-47}$$

$$\boldsymbol{\sigma_G^2} \approx \begin{bmatrix} n(\phi^2\sigma_c^2 + \sigma_d^2) \\ n(\phi^2\sigma_c^2 + \sigma_d^2) \end{bmatrix} + \phi^2 \sum_{j=1}^{n} \left(\frac{1-\rho^{n+1-j}}{1-\rho}\right)^2 \mathbb{P}^j \boldsymbol{\sigma_x^2}.$$

We acknowledge that the expression for $\boldsymbol{\sigma_G^2}$ is not exact because we are ignoring the variance component associated with uncertainty about $\mu(S_{t+j})$.

The expressions in (A-46) allow us to calculate the Sharpe ratio

$$SR_{n,t} = \frac{e_{n,t} + E_t[g_{d,t+n}] - y^r_{n,t}}{\sqrt{V_t[g_{d,t+n}]}} \tag{A-48}$$

In the main text, we report the case of $x_t = 0$ for ease of illustration, e.g., $E_t g_{d,t+n}|_{x_t=0}$ and $V_t g_{d,t+n}|_{x_t=0}$.

A.7.7 Market Return

We derive the market return via Campbell-Shiller approximation

$$\begin{aligned} r_{m,t+1} &= \kappa_0 + \kappa_1 z_{m,0}(S_{t+1}) - z_{m,0}(S_t) + \bar{\mu}(1-\phi) + \phi\mu(S_{t+1}) \\ &\quad + (\phi\rho + \kappa_1 z_{m,1}(S_{t+1})\rho - z_{m,1}(S_t))x_t \\ &\quad + (\phi + \kappa_1 z_{m,1}(S_{t+1}))\sigma_x(S_{t+1})\epsilon_{t+1} + \phi\sigma_c\eta_{c,t+1} + \sigma_d\eta_{d,t+1} \end{aligned} \tag{A-49}$$

where the log price-dividend ratio is given by

$$z_t = z_{m,0}(S_t) + z_{m,1}(S_t)x_t. \tag{A-50}$$

The market equity premium is

$$\begin{aligned} E_t[r_{m,t+1}] - y^r_{n,t} + \frac{1}{2}V_t[r_{m,t+1}] &= -Cov_t(r_{m,t+1}, m_{t+1}) \\ &= \mathbb{P} \times \begin{bmatrix} (\phi + \kappa_1 z_{m,1}(1))\sigma_x(1)\lambda(1) \\ (\phi + \kappa_1 z_{m,1}(2))\sigma_x(2)\lambda(2) \end{bmatrix}. \end{aligned} \tag{A-51}$$

The conditional variance of the market return is

$$V_t[r_{m,t+1}] \approx \begin{bmatrix} \phi^2\sigma_c^2 + \sigma_d^2 \\ \phi^2\sigma_c^2 + \sigma_d^2 \end{bmatrix} + \mathbb{P} \times \begin{bmatrix} (\phi + \kappa_1 z_{m,1}(1))^2\sigma_x(1)^2 \\ (\phi + \kappa_1 z_{m,1}(2))^2\sigma_x(2)^2 \end{bmatrix}. \tag{A-52}$$

The market Sharpe ratio is

$$SR_t = \frac{E_t[r_{m,t+1}] - y^r_{n,t}}{\sqrt{V_t[r_{m,t+1}]}}. \tag{A-53}$$

Here, we are not accounting for $\frac{1}{2}V_t[r_{m,t+1}]$ in the numerator.

A.7.8 Calibration

With this calibration, we derive the market return via Campbell-Shiller approximation and compute the expected excess return of the market. The equity premium is 4.13 and 18.60 in expansion and recession, respectively. The unconditional average (weighted by steady state probability) is around 6.29.

Table A.9: Calibration

Parameters

$\mu(1)$	0.0020	ρ	0.50	$\lambda(1)$	0.1315
$\mu(2)$	0.0010	$\sigma_x(1)$	0.0033	$\lambda(2)$	0.2789
σ_c	0.0063	$\sigma_x(2)$	0.0070	$r(1)$	0.0019
ϕ	4.0	p_1	0.9965	$r(2)$	0.0019
σ_d	0.0173	p_2	0.98		

Simulated moments

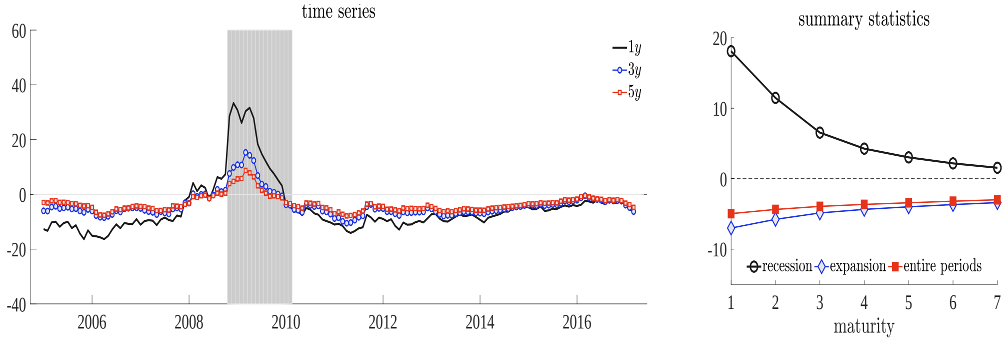
	data	model		
		50%	[5%	95%]
$E(\Delta c)$	1.83	2.24	[1.35	3.08]
$\sigma(\Delta c)$	2.19	2.82	[2.13	3.65]
$\rho(\Delta c)$	0.48	0.24	[0.01	0.46]
$E(\Delta d)$	1.00	2.26	[-1.85	5.96]
$\sigma(\Delta d)$	11.15	12.34	[9.89	15.64]
$\rho(\Delta d)$	0.20	0.23	[0.01	0.45]

Notes: Top panel - The steady state probabilities for the expansion and recession states are $(1-p_2)/(2-p_1-p_2) = 0.8511$ and $(1-p_1)/(2-p_1-p_2) = 0.1489$, respectively. The steady state consumption growth mean is $\bar{\mu} = (1-p_2)/(2-p_1-p_2)\mu(1)+(1-p_1)/(2-p_1-p_2)\mu(2) = 0.0019$. Risk-free rate coefficients are $r(1) = r(2) = \bar{\mu}$. Bottom panel - The table is constructed based on $T = 50$ years of simulated data which is repeated $N = 10,000$ times.

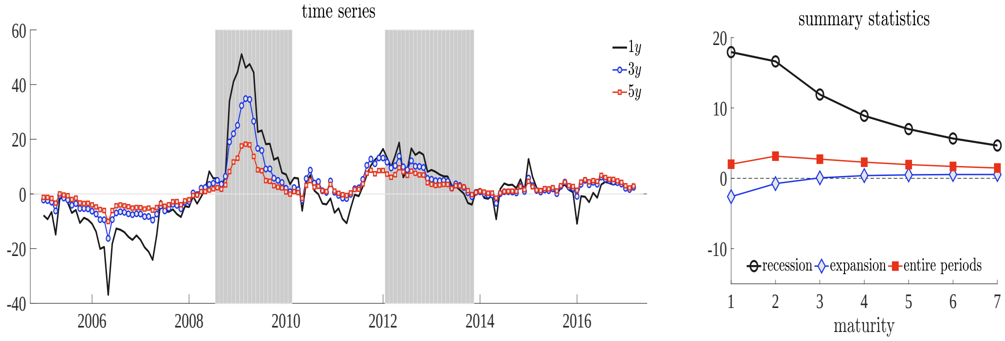
A.8 Supplementary Figures and Tables

Figure A.1: Forward Equity Yields

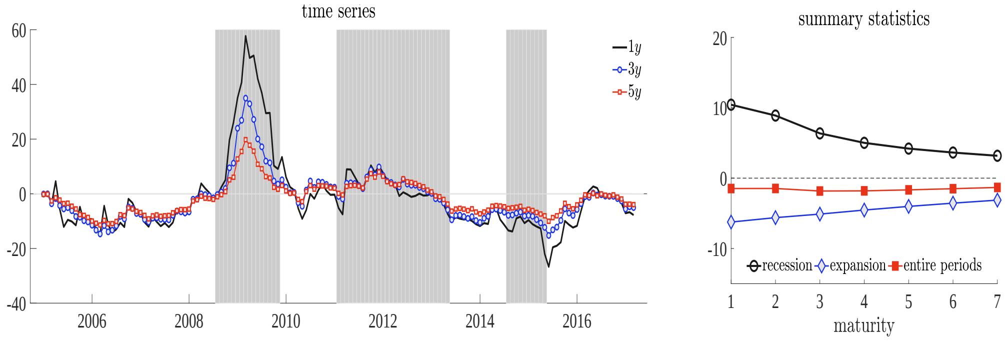
US: S&P 500



Europe: Eurostoxx 50

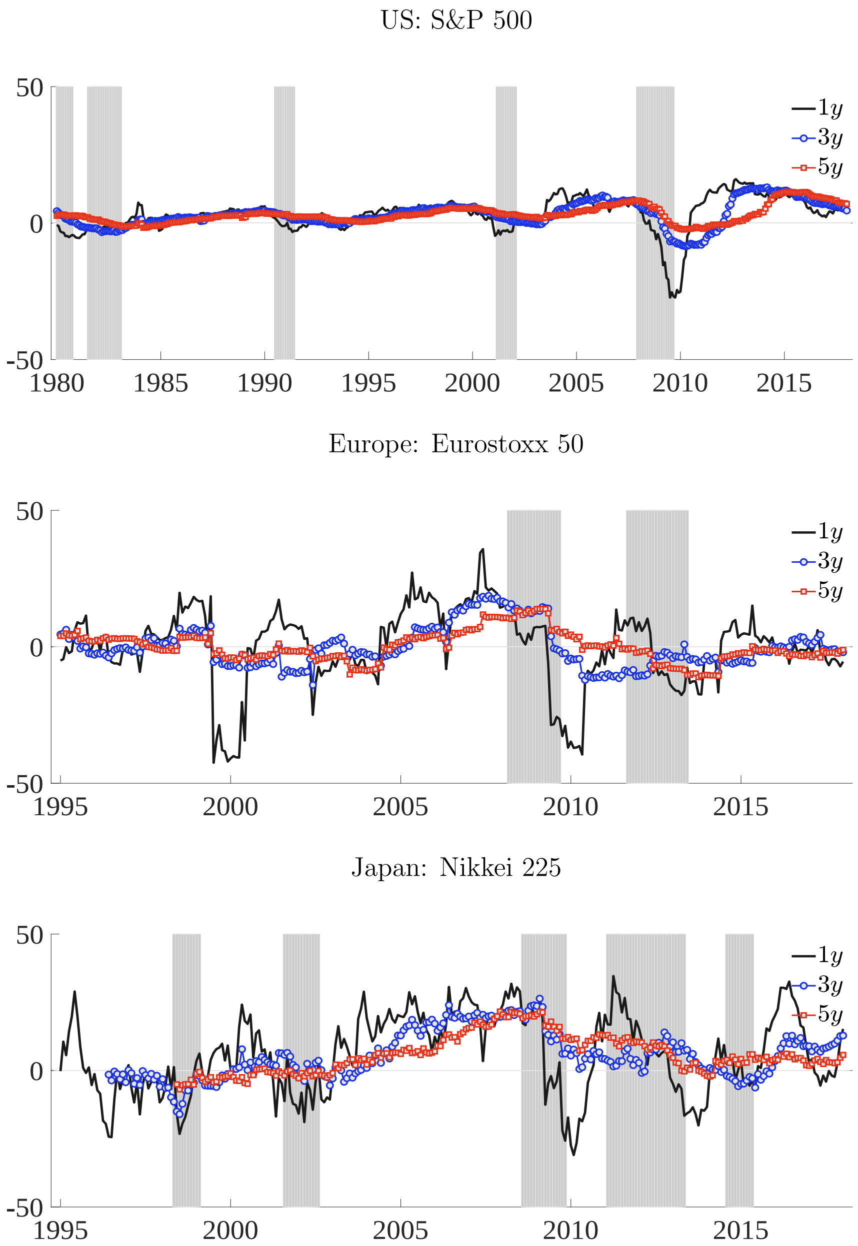


Japan: Nikkei 225



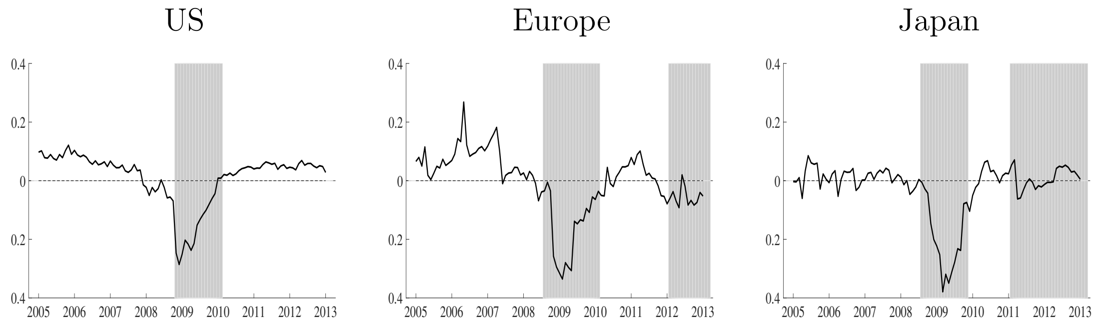
Notes: We provide the time series of the forward equity yields from 2004:M12 to 2017:M2. Equity yields are $e^f_{n,t} = \frac{1}{n}\ln(\frac{D_t}{F_{n,t}})$ with $F_{n,t}$ the futures price and D_t the trailing sum of 12 month dividends.

Figure A.2: Dividend Growth: Time Series Evidence



Notes: For US, dividend growth data are available from 1979:M12 to 2017:M2 for all horizons. For Europe, dividend growth data are available from 1994:M12 to 2017:M2 for all horizons. For Japan, 1-year dividend growth data are available starting from 1994:M12, 3-year dividend growth data from 1996:M5, and 5-year dividend growth from 1998:M5. Data end in 2017:M2. Shaded bars indicate recession dates. The provider for the recession dates 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.

Figure A.3: The Equity Yield Spread Between 5y and 1y



Notes: Shaded bars indicate recession dates. Negative spread coincides with recession. The prediction sample starts from 2005:M1 to 2013:M2.

Table A.10: The Expected Dividend Growth Rates and the Expected Excess Returns: U.S.

	RMSE		Premium		Exp. return		Sharpe Ratio		Exp. growth		STRIPS	YLD	INF
horizon	SSP	LSP	SSP	LSP	SSP	LSP	SSP	LSP	SSP	LSP			
Entire period													
1y	8.41	9.82	1.43	1.22	1.46	1.26	0.19	0.14	4.01	3.80	-4.58	2.04	2.00
2y	9.51	8.60	2.22	1.95	2.39	2.13	0.37	0.24	4.18	3.91	-3.96	2.17	2.00
3y	9.19	7.03	2.65	2.39	3.02	2.76	0.48	0.34	4.31	4.05	-3.66	2.37	2.00
4y	8.20	5.87	2.94	2.69	3.53	3.28	0.56	0.44	4.40	4.14	-3.46	2.59	2.00
5y	6.73	4.68	3.21	2.95	4.04	3.78	0.63	0.54	4.47	4.21	-3.26	2.83	2.00
5y-1y	-	-	1.78	1.72	2.58	2.52	0.44	0.40	0.46	0.41	1.32	0.79	-
Positive strips spread													
1y	5.90	5.24	-0.60	-1.86	-0.30	-1.57	-0.08	-0.21	7.71	6.44	-10.31	2.29	2.00
2y	8.41	7.01	1.58	-0.58	1.97	-0.20	0.27	-0.07	7.21	5.05	-7.64	2.39	2.00
3y	8.65	6.72	2.69	0.53	3.23	1.06	0.49	0.08	6.83	4.66	-6.14	2.53	2.00
4y	7.55	5.90	3.16	1.19	3.88	1.91	0.60	0.20	6.53	4.56	-5.37	2.72	2.00
5y	5.82	4.66	3.47	1.71	4.39	2.62	0.68	0.31	6.30	4.53	-4.83	2.92	2.00
5y-1y	-	-	4.07	3.57	4.69	4.18	0.76	0.52	-1.41	-1.91	5.48	0.62	-
Negative strips spread													
1y	13.33	17.41	7.59	10.61	6.84	9.87	1.01	1.21	-7.25	-4.23	12.84	1.26	2.00
2y	12.12	12.16	4.17	9.67	3.69	9.19	0.70	1.19	-5.05	0.45	7.22	1.52	2.00
3y	10.51	7.84	2.52	8.06	2.39	7.93	0.46	1.15	-3.37	2.17	3.89	1.87	2.00
4y	9.77	5.71	2.28	7.24	2.48	7.44	0.43	1.18	-2.08	2.88	2.36	2.20	2.00
5y	8.85	4.66	2.41	6.73	2.99	7.31	0.47	1.20	-1.08	3.24	1.49	2.58	2.00
5y-1y	-	-	-5.17	-3.87	-3.85	-2.55	-0.54	-0.01	6.17	7.48	-11.34	1.32	-

Notes: Tables are generated from models that are estimated from 2005:M1 to 2017:M2 sample. We show two approaches: (1) SSP and (2) BMY, i.e., a 3-variable VAR approach that includes the 5y-1y nominal bond spread, asset dividend to earnings ratio, and dividend growth.

Table A.11: The Expected Dividend Growth Rates and the Expected Excess Returns: Europe

	RMSE		Premium		Exp. return		Sharpe Ratio		Exp. growth		STRIPS	YLD	INF
horizon	SSP	LSP	SSP	LSP	SSP	LSP	SSP	LSP	SSP	LSP			
Entire period													
1y	8.46	7.59	3.70	2.76	3.56	2.62	0.47	0.38	-0.53	-1.47	2.12	1.96	2.10
2y	10.24	7.10	5.08	4.30	5.07	4.30	0.68	0.63	-0.80	-1.58	3.78	2.09	2.10
3y	9.11	6.38	4.16	3.33	4.33	3.50	0.55	0.51	-0.89	-1.72	2.95	2.27	2.10
4y	6.32	4.26	3.37	2.46	3.76	2.84	0.46	0.41	-0.90	-1.81	2.17	2.49	2.10
5y	4.98	3.07	2.83	1.83	3.37	2.37	0.40	0.33	-0.88	-1.88	1.61	2.64	2.10
5y-1y	-	-	-0.87	-0.93	-0.18	-0.24	-0.08	-0.05	-0.36	-0.42	-0.51	0.68	-
Positive strips spread													
1y	6.39	7.61	2.01	0.85	2.46	1.30	0.26	0.12	8.55	7.39	-8.64	2.55	2.10
2y	10.34	8.14	3.05	1.06	3.58	1.59	0.41	0.16	5.90	3.91	-4.94	2.63	2.10
3y	9.99	7.43	3.19	0.87	3.85	1.53	0.42	0.13	4.23	1.91	-3.14	2.77	2.10
4y	7.00	4.60	2.95	0.60	3.78	1.44	0.40	0.10	3.14	0.80	-2.29	2.93	2.10
5y	5.24	3.08	2.63	0.38	3.60	1.35	0.37	0.07	2.42	0.17	-1.89	3.06	2.10
5y-1y	-	-	0.62	-0.47	1.14	0.05	0.11	-0.05	-6.13	-7.22	6.75	0.52	-
Negative strips spread													
1y	10.49	7.48	5.90	5.25	4.99	4.34	0.76	0.72	-12.42	-13.07	16.22	1.19	2.10
2y	9.99	5.40	7.73	8.54	7.02	7.83	1.03	1.26	-9.58	-8.77	15.21	1.39	2.10
3y	7.68	4.61	5.43	6.56	4.95	6.08	0.72	1.01	-7.59	-6.46	10.92	1.62	2.10
4y	5.23	3.76	3.92	4.88	3.73	4.69	0.53	0.81	-6.20	-5.24	8.02	1.91	2.10
5y	4.56	3.05	3.08	3.72	3.08	3.72	0.43	0.67	-5.21	-4.57	6.19	2.10	2.10
5y-1y	-	-	-2.81	-1.53	-1.91	-0.62	-0.32	-0.05	7.21	8.50	-10.03	0.90	-

Notes: Tables are generated from models that are estimated from 2005:M1 to 2017:M2 sample. We show two approaches: (1) SSP and (2) BMY, i.e., a 3-variable VAR approach that includes the 5y-1y nominal bond spread, dividend to price ratio, and dividend growth.

Table A.12: The Expected Dividend Growth Rates and the Expected Excess Returns: Japan

	RMSE		Premium		Exp. return		Sharpe Ratio		Exp. growth		STRIPS	YLD	INF
horizon	SSP	LSP	SSP	LSP	SSP	LSP	SSP	LSP	SSP	LSP			
Entire period													
1y	11.62	12.79	8.86	11.99	8.91	12.04	0.73	0.87	6.45	9.58	2.18	0.28	0.23
2y	9.91	8.70	8.88	11.25	9.02	11.39	0.94	1.27	7.07	9.44	1.57	0.38	0.23
3y	7.96	6.78	8.28	9.80	8.53	10.05	0.97	1.34	7.55	9.08	0.49	0.49	0.23
4y	5.68	5.22	8.11	8.97	8.50	9.35	1.01	1.38	7.93	8.78	-0.04	0.62	0.23
5y	4.44	3.93	8.17	8.46	8.68	8.97	1.06	1.42	8.22	8.51	-0.28	0.74	0.23
5y-1y	-	-	-0.69	-3.53	-0.24	-3.08	0.33	0.55	1.77	-1.07	-2.46	0.46	-
Positive strips spread													
1y	12.60	13.39	5.43	5.07	5.49	5.12	0.44	0.37	11.51	11.14	-6.31	0.29	0.23
2y	8.47	8.33	6.54	5.30	6.71	5.47	0.70	0.60	11.25	10.01	-4.94	0.40	0.23
3y	7.65	7.02	7.08	5.55	7.36	5.83	0.83	0.76	11.05	9.52	-4.20	0.51	0.23
4y	5.81	4.55	7.43	5.63	7.84	6.04	0.92	0.87	10.90	9.10	-3.70	0.64	0.23
5y	4.37	2.61	7.77	5.76	8.30	6.29	1.00	0.97	10.79	8.78	-3.25	0.76	0.23
5y-1y	-	-	2.34	0.70	2.81	1.16	0.56	0.60	-0.72	-2.37	3.06	0.47	-
Negative strips spread													
1y	10.62	12.33	12.67	19.67	12.71	19.71	1.04	1.42	0.83	7.84	11.61	0.27	0.23
2y	11.31	9.14	11.48	17.75	11.59	17.95	1.22	2.01	2.45	8.81	8.80	0.35	0.23
3y	8.21	6.44	9.60	14.45	9.83	14.73	1.13	1.98	3.68	8.58	5.69	0.46	0.23
4y	5.50	5.82	8.87	12.59	9.23	13.03	1.10	1.95	4.63	8.42	4.01	0.59	0.23
5y	4.47	4.96	8.62	11.46	9.09	11.93	1.11	1.92	5.37	8.21	3.01	0.71	0.23
5y-1y	-	-	-4.06	-8.22	-3.62	-7.78	0.08	0.50	4.54	0.38	-8.59	0.44	-

Notes: Tables are generated from models that are estimated from 2005:M1 to 2017:M2 sample. We show two approaches: (1) SSP and (2) BMY, i.e., a 3-variable VAR approach that includes the 5y-1y nominal bond spread, dividend to price ratio (pd12SPXD1), and dividend growth.

Table A.13: The Spread Between 5-Year and 1-Year Forecasts: The SSP Approach

	Exp. return			Exp. growth		
	50%	[5%	95%]	50%	[5%	95%]
			Entire period			
U.S.	2.58*	[0.80,	3.60]	0.19	[-1.23,	1.57]
Europe	-0.18	[-2.86,	1.73]	-0.36	[-2.96,	1.63]
Japan	-0.24	[-3.44,	1.78]	1.77	[-1.41,	3.81]
			Expansion period			
U.S.	4.69*	[2.16,	5.83]	-1.41*	[-2.88,	-0.22]
Europe	1.14	[-0.41,	2.80]	-6.13*	[-8.67,	-4.46]
Japan	2.81	[-0.26,	3.49]	-0.72*	[-2.79,	-0.08]
			Recession period			
U.S.	-3.85*	[-4.40,	-1.07]	6.17*	[4.72,	7.95]
Europe	-1.91	[-4.45,	0.65]	7.21*	[5.68,	10.75]
Japan	-3.62*	[-5.92,	-0.16]	4.54*	[2.42 ,	8.18]

Notes: We provide the SSP results based on the in-sample forecasts. The estimation sample is from 2005:M1 to 2017:M2. Our prediction sample is from 2005:M1 to 2013:M2. We use $*$ to indicate the statistical significance at the 90% confidence level.

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