Internet Appendix for
"Duration-Driven Returns"

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ABSTRACT

Section I of this Internet Appendix studies the pricing of risk factors in the model by Lettau and Wacther (2007). Section II provides additional tests of the duration factor. Section III studies the performance on other anomalies in our three-factor model. Section IV studies the empirical behavior of the equity yield curve. The Internet Appendix also contains supplementary Tables and Figures.

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Appendix I. Duration-Driven Returns in the Lettau and Wachter (2007) Model

In this section, we show that the major equity risk factors all arise in the Lettau and Wachter (2007) model. In this model, the equity term structure is downward-sloping because the cash-flow risk is higher on near-future cash flows than on distant-future cash flows, and because discount-rate risk is not priced.

A. Model

The economy has an aggregate equity claim with dividends at time t denoted by D_t, where $d_t = \ln(D_t)$ evolves according to

$$\Delta d_{t+1} = \mu_g + z_t + \sigma_d \epsilon_{d,t+1}. \tag{IA.1}$$

Here, $\mu_g \in \mathbb{R}$ is the unconditional mean dividend growth and z_t drives the conditional mean,

$$z_{t+1} = \varphi_z z_t + \sigma_z \epsilon_{z,t+1}, \tag{IA.2}$$

where $0 < \varphi_z < 1$. Further, $\epsilon_{d,t+1}$ and $\epsilon_{z,t+1}$ are normally distributed mean-zero shocks with unit variance and σ_d, σ_z are their volatilities.

The risk-free rate r^f is constant and the stochastic discount factor is given by

$$M_{t+1} = \exp\left(-r^f - \frac{1}{2}x_t^2 - x_t \epsilon_{d,t+1}\right), \tag{IA.3}$$

where the state variable x_t drives the price of risk,

$$x_{t+1} = (1-\varphi_x)\bar{x} + \varphi_x x_t + \sigma_x \epsilon_{x,t+1}. \tag{IA.4}$$

The parameter $\bar{x} \in \mathbb{R}^+$ is the long-run average, $0 < \varphi_x < 1$, $\epsilon_{x,t+1}$ is a normally distributed mean-zero shock with unit variance, and σ_x is the volatility. The three shocks have correlations denoted by ρ_{dx}, ρ_{dz}, and ρ_{zx}, where $\rho_{zx} = 0$, $\rho_{dx} = 0$, and $\rho_{dz} < 0$, which means that there is long-run insurance in dividend growth: a negative shock to dividends is over time partly offset by higher dividend growth.

To understand the stochastic discount factor, note that investors are averse to shocks to dividends, $\epsilon_{d,t+1}$. A negative shock to dividends increases marginal utility and thus increases the value of the stochastic discount factor. The effect of a given shock on the stochastic discount factor depends on the price-of-risk variable x_t, which in this sense can be interpreted as a risk-aversion variable. In addition, shocks to the price of risk and the conditional growth rate z_t are priced only to the extent that they are correlated with the dividend shock.

B. Prices and Returns

The analysis is centered around the prices and returns on n-maturity dividend claims. The price of an n-maturity claim at time t is denoted by P_t^n, and the log-price is denoted by $p_t^n = \ln(P_t^n)$. Since an n-maturity claim becomes an $n-1$ maturity claim next period, we have the following relation for prices:

$$P_t^n = E_t\left[M_{t+1}P_{t+1}^{n-1}\right], \tag{IA.5}$$

with boundary condition $P_t^0 = D_t$, because the dividend is paid out at maturity. To solve the model, we conjecture and verify that the price-dividend ratio is log-linear in the state variables z_t and x_t:

$$\frac{P_t^n}{D_t} = \exp\left(A^n + B_z^n z_t + B_x^n x_t\right). \tag{IA.6}$$

The price-dividend ratio can then be written as

$$\frac{P_t^n}{D_t} = E_t\left[M_{t+1}\frac{D_{t+1}}{D_t}\frac{P_{t+1}^{n-1}}{D_{t+1}}\right] = E_t\left[M_{t+1}\frac{D_{t+1}}{D_t}\exp\left(A^{n-1} + B_z^{n-1}z_{t+1} + B_x^{n-1}x_{t+1}\right)\right]. \tag{IA.7}$$

Matching coefficients of (IA.6) and (IA.7), using (IA.1) and (IA.4), gives

$$\begin{aligned}
A^n &= A^{n-1} - r^f + \mu_g + B_x^{n-1}(1-\varphi_x)\bar{x} + \frac{1}{2}V^{n-1},\\
B_x^n &= B_x^{n-1}\left(\varphi_x - \rho_{dx}\sigma_x\right) - \sigma_d + B_z^{n-1}\rho_{dz}\sigma_z,\\
B_z^n &= \frac{1-(\varphi)_z^n}{1-\varphi_z},
\end{aligned}$$

where $B_x^0 = 0$, $A^0 = 0$, and

$$V^{n-1} = \text{var}\left(\sigma_d\epsilon_{d,t+1} + B_z^{n-1}\sigma_z\epsilon_{z,t+1} + B_x^{n-1}\sigma_x\epsilon_{x,t+1}\right),$$

which provides the solution to the model and verifies the conjecture.

The term B_z^n is positive for all values of $n > 0$, which implies that the price increases relative to dividends when the expected growth rate of dividends increases. Similarly, B_x^n is negative for all values of $n > 0$, meaning that the price relative to dividends decreases when the price of risk is higher.

The simple return on the n maturity claim is denoted by $R_{t+1}^n = P_{t+1}^{n-1}/P_t^n - 1$, and the log-return is $r_{t+1}^n = \ln\left(1 + R_{t+1}^n\right)$. The expected excess return is

$$E_t\left[r_{t+1}^n - r^f\right] + \frac{1}{2}\mathrm{var}_t(r_{t+1}^n) \tag{IA.8}$$

$$= -\,\mathrm{cov}_t(r_{t+1}^n; m_{t+1}) \tag{IA.9}$$

$$= (\sigma_d + B_z^{n-1}\rho_{dz}\sigma_z)x_t. \tag{IA.10}$$

Because $\rho_{dz} < 0$ and B_z^n is strictly increasing in maturity n, the expected return decreases in maturity. Accordingly, the term structure of expected equity returns is downward-sloping.

C. The Cross-Section of Stock Returns

Following Lettau and Wachter (2007), we introduce a cross-section of stocks by assuming the existence of $i = 1, \ldots, N$ firms that each produce a share s_t^i of the aggregate dividends. The share produced by each firm varies deterministically over time as the firms move through their life cycles. The share starts at $\underline{s}$ and grows at g_s each period until the share hits $\bar{s} = \underline{s} \times (1 + g_s)^{N/2}$, after which it decreases by g_s until the share hits $\underline{s}$ and the cycle repeats. The lower bar is set such that the shares sum to one cross-sectionally, meaning that $\underline{s} + \underline{s}(1 + g_s)^{N/2} + \sum_{i=1}^{N/2-1}(1 + g_s)^i\underline{s} = 1$. We assume $N = 200$ firms, which implies that each firm has a life cycle of 50 years. The firms are identical except that they are at different points in their life cycle: the first firm starts at $\underline{s}$, the next firm has grown for one quarter, and so on.

Given no-arbitrage, the price of each firm is its share of future dividends times their present value,

$$P_t^i = \sum_{n=1}^{\infty} s_{t+n}^i P_t^n, \tag{IA.11}$$

and the one-period return is given by the end-of-period price plus the share of the aggregate dividend received at the end of the period, divided by the beginning-of-period price,

$$R_{t+1}^{i} = \frac{P_{t+1}^{i} + s_{t+1}^{i} D_{t+1}}{P_{t}^{i}}. \tag{IA.12}$$

To construct equity risk factors, we must calculate the book value of equity. We consider book value of equity as a measure of fundamental value that does not account for time-varying discount rates. Accordingly, we calculate book value as the present value of future dividends discounted using the unconditional average market risk premium. We then calculate investment as the quarterly change in book value, we calculate profitability as the dividends currently earned by the firm divided by lagged book value of equity, and we calculate book-to-market as the book value divided by the market value of equity. In addition, we calculate momentum as the running one-year return (skipping the most recent month), and we calculate betas as rolling three-year betas.

D. Results in Simulated Data

To study the cross-section of stock returns, we run 1,000 simulations of 700 quarters of artificial data. For each simulation, we sort stocks each period into equal-weighted quintile portfolios based on profitability, investment, book-to-market, market capitalization, and market beta. We then construct risk factors as long-short portfolios based on the first and fifth quintiles. For each simulation, we run CAPM regressions and calculate median intercepts and parameter estimates across the simulations. We also calculate the duration of each factor as the difference between the duration of the long and the short legs of the factor. When calculating the duration of the individual firms, we only consider the following 100 quarters of cash flows — for practical reasons, our firms never die, but when calculating the duration of the cash flows we want to ensure that we are not including the cash flows of its subsequent life cycle, which we would do if looking at all future cash flows. The duration of a firm's cash flows is thus given by

$$D = \frac{\mathbf{Y}'\mathbf{P}}{\mathbf{e}'\mathbf{P}}, \tag{IA.13}$$

where $\mathbf{Y}' = [0.25, \ldots, 25]$ is a column vector of quarters, $\mathbf{P}$ is a row vector of present values of dividends, and $\mathbf{e}'$ is a column vector with $1/100$ in each column.

The CAPM alphas are reported in Table IA.V The risk factors based on valuation, profitability, investment, and beta all have positive CAPM alphas of 0.2 to 0.6% per month. Accordingly, our model of the downward-sloping equity term structure is able to explain the well-known CAPM alpha associated with these characteristics.

The factors have positive alpha because they are all long short-duration stocks and short long-duration stocks. Indeed, as can be seen in the bottom row of Table IA.V, the duration is between -3 and -14 for the above-mentioned factors. This difference between the duration of the long and short legs of the factors is large given that we use only 25 years to calculate duration.

In our model, the links between the risk factors and duration are as follows:

- *Profitability*: In our setting, a high-profitability firm has high dividends relative to book value, which summarizes the total value of future dividends. If dividends are high today relative to future dividends, it means that the firm is at the peak of its life cycle and therefore has relatively short duration.

- *Investment*: A high-investment firm has large growth in book value, which means it has large growth in the value of future dividends. Firms with large growth in the value of future dividends are usually at the beginning of their life cycle and therefore are long-duration stocks.

- *Book-to-market (value)*: A value firm has a low price of future dividends, which means its discount rate is high. Discount rates are higher for short-duration claims because the equity term structure is downward-sloping. Accordingly, value firms tend to have short cash-flow duration. It is worth noting that value firms have short duration only because the equity term structure is downward-sloping. Had it been upward-sloping, value firms would have had long duration (as long-duration stocks would have had high discount rates and endogenously become value stocks).

- *Size*: Small firms have long duration because they are at the beginning of their life cycle and are expected to experience large growth in dividends.

- *Low beta*: In our model, long-duration stocks have high betas because they are more exposed to the discount-rate shock, $\epsilon_{x,t+1}$, and the growth rate shock $\epsilon_{z,t+1}$, as seen in equation (IA.8) (the loadings on the shocks, B_x^n and B_z^n, both increase in absolute terms in maturity n, although B_x^n increases nonmonotonically). Accordingly, a low-beta stock tends to be a short-duration stock.

While the Lettau and Wachter (2007) model of a downward-sloping term structure is proposed to explain the value premium, the model appears better suited to explain profitability and investment premia for multiple reasons. First, the profit and investment factors have larger alphas in our model than the value factor. Second, the returns to the profit and investment factors are more directly related to the slope of the equity term structure. Indeed, in a hypothetical upward-sloping model, the profit and investment factors have negative expected returns, whereas the value factor still has positive expected returns. The positive expected returns to the value factor remain because the factor now goes long the long-duration stocks (the book-to-market ratio now identifies the long-duration stocks as endogenously cheap stocks with high expected returns). In the empirical section, we take care not to use market prices when estimating duration to avoid this problem of endogenously identifying firms with high expected returns as short-duration stocks.

Appendix II. Additional Tests for the Duration Factor

In this section, we subject our duration factor to the test of new factors from Feng, Giglio, and Xiu (2020, FGX). This test is specifically designed to provide a "conservative and productive way to screen new factors and bring discipline to the 'zoo of factors'" (p. 1359).

FGX use a two-pass (or "double-selection") lasso to select a set of control factors $h_t \in \mathbb{R}^p$ against which a proposed new factor $g_t \in \mathbb{R}$ is compared. With these control factors in hand, a cross-sectional regression is used to estimate the loading λ_g on the new factor in the stochastic discount factor, which corresponds to its usefulness in explaining the cross-section over and above the benchmark factors h_t.[1] We set $g_t = r_t^{DUR}$, and for the "zoo" of possible control factors, we use FGX's library of 150 risk factors (excluding the two factors for which there are multiple years of missing data), along with our small-minus-big factor constructed from duration-sorted portfolios as in (6).[2] For test assets, we use the same 750 characteristic-sorted portfolios used by FGX. Their risk factors and test assets are available

[1] The cross-sectional regression is $\bar{r} = \iota_n \alpha + \widehat{\mathrm{Cov}}(r_t, h_t)\lambda_h + \widehat{\mathrm{Cov}}(r_t, g_t)\lambda_g + u$, where $r_t \in \mathbb{R}^n$ is a vector of test-asset returns, $\bar{r}$ is its time-series average, and $\iota_n \in \mathbb{R}^n$ is a vector of ones. For further details on the test and its interpretation, see FGX (2020).

[2] We use our smb factor as a possible control so as to isolate the contribution of our main factor r_t^{DUR}, as the FGX procedure is meant to "focus on the evaluation of a *new factor*, rather than testing or estimating an entire reduced-form asset pricing model" (p. 1332). In our case, the double-selection lasso selects 117 factors to include as controls. And the two excluded control factors are the dividend initiation and dividend omission factors; we exclude them because the test drops any observations with at least one missing factor return, so the inclusion of these two factors effectively shortens the test's sample size by multiple years.

monthly from July 1976 through December 2017, so we restrict attention to this sample period for r_t^{DUR} so that our estimation follows theirs as closely as possible.[3]

Table IA.VIII presents estimation results for λ_{DUR}. This loading corresponds to the estimated average excess return, in basis points (bps) per month, for a portfolio with a univariate beta with respect to r_t^{DUR} normalized to 1, following FGX. The first column shows that in the baseline double-selection test, the duration factor has a risk premium λ_{DUR} of 235.3 bps per month ($t = 3.05$), suggesting that the factor provides highly significant explanatory power. For comparison, only two other factors considered in FGX's post-2012 empirical application — the profit factors of Fama and French (2015) and Hou, Xue, and Zhang (2015) — have higher t-statistics, but they have lower point estimates of $\lambda = 160$ and 77 bps per month, respectively.[4]

The second column in Table IA.VIII presents results for λ_{DUR} estimated using only the three Fama and French (1993) factors (FF3) as controls. In this case the estimate for λ_{DUR} is smaller but more precise. The third column includes all 149 possible factors as controls and shows that the OLS estimate of λ_{DUR} remains quite high and significant at the 1% level. In both the FF3 and no-selection cases, the duration factor outperforms all post-2012 factors considered by FGX, in terms of both its point estimate and t-statistic.

These results provide evidence that the duration factor contributes significantly in explaining returns in the cross-section, even in a conservative high-dimensional test. How might this finding arise, given that the duration factor is constructed using sorts based on a linear combination of characteristics used for previously proposed factors? At a statistical level, the portfolio construction using 2×3 sorts means that the duration factor return is not mechanically spanned by other factors' returns. At a deeper level, though, the duration factor appears to exploit an economically useful combination of the underlying characteristics used in its construction.

Appendix III. Explaining Anomalies with the Duration Factor

In this section, we examine whether our duration factor can explain risk factors other than those in Table IA.IV. To this end, we use 54 factors based on the characteristics

[3]We thank the authors for making their data available, and for their assistance with the code used to implement their estimation procedure.

[4]FGX evaluate only factors proposed post-2012 in their main analysis.

studied in Freyberger, Neuhierl, and Weber (2020).[5] We consider all of the characteristics studied in that paper, except the characteristics already considered above, as well as the momentum characteristic, given that momentum is not plausibly related to or explained by a fundamental characteristic like cash-flow duration. We then discard all of the factors that do not have significant CAPM alpha, resulting in a total of 25 factors.[6] We then study how well our duration factor explains these anomalies.

Table IA.VI shows the performance of the 25 CAPM anomalies in our three-factor model, which includes the market, our size factor, and our duration factor. For each anomaly, we report the alpha in monthly percent along with the p-value of the hypothesis that the alpha is statistically insignificant. However, we are considering 25 factors, and some of these might remain significant by chance, so judging significance simply from the p-values would result in too many false positives. Instead, we employ the Benjamini and Hochberg (1995) procedure to account for false discovery arising from multiple testing.[7] As can be seen in Table IA.VI, only 7 of the 25 factors remain statistically significant when using the Benjamini and Hochberg procedure at a nominal false discovery rate of 5%.

Appendix IV. The Equity Yield Curve

We next study the book-to-market ratios of long- and short-duration firms. These book-to-market ratios together constitute the equity yield curve. Indeed, Binsbergen et al. (2013) define equity yields as the hold-to-maturity return minus hold-to-maturity growth rates of dividends with different maturities. Similarly, book-to-market ratios of duration-

[5] We use the dataset constructed by Freyberger, Neuhierl, and Weber (2020), and we thank the authors for sharing their data.

[6] Many factors exist only among small-cap firms and in extreme portfolio sorts, which means they do not show up when considering Fama and French (1993) portfolios.

[7] This approach ensures that when testing multiple hypotheses, the false discovery rate, or number of false positives, is kept at a certain threshold, usually 5%. This approach entails ranking all the p-values in ascending order and associating them with a critical value that depends on the rank. One then looks for the highest p-value that is below its critical value, and concludes that all hypotheses with lower p-values are significant at the desired level. For 5%-level tests, critical values are given by $5\% \times \text{rank}/25$. Accordingly, the critical value for the first hypothesis (the one with the lowest p-value and rank 1) is the Bonferroni critical value, and the critical value for the last hypothesis (the one with the highest p-value and rank 25) is the usual 5% critical value.

sorted portfolios measure the future expected return and growth rate of firms with different cash-flow duration (Vuolteenaho (2002)).

We calculate the level of the equity yield curve as the average log book-to-market ratio of the four portfolios that constitute the duration factor. Similarly, we calculate the slope of the equity yield curve as the average log book-to-market ratio of the two long-duration portfolios in the duration factor minus the average log book-to-market ratio of the two short-duration portfolios in the duration factor.

Figure IA.4 plots the slope of the equity yield curve. As can be seen from the figure, the slope is positive at the beginning of the sample. From 1960 and thereafter, it fluctuates around zero. These results are consistent with cumulative excess returns to our duration factor in Figure 4, where the long-duration stocks have high returns in the early sample.

Figure IA.4 also plots the slope of the Treasury yield curve, measured as the difference in yields between all outstanding long- and short-duration Treasuries. Because the CRSP tape of Treasury yields does not start until the 1950s, we create our own estimates of these yields in the early sample. We define long-duration Treasuries as all Treasuries with maturity of more than 10 years. We define short-duration Treasuries as all Treasuries with maturity of less than 5 years.[8] We value-weight the yields based on the total value of each outstanding Treasury security.

Panel A of Table IA.VII shows results from regressions of the slope of the equity yield curve onto the slope of the bond yield curve. For the full sample, considered in the leftmost column, the relation is weak. However, in both the early sample, from 1929 to 1974, and the late sample, from 1995 to 2018, the relation is strong, with R^2s of 0.65 and 0.59, respectively. During the relatively high-inflation period from 1974 to 1995, the correlation between the slopes is substantially lower, but this is natural as the slope of the equity yield curve should not be as closely linked to inflation risk premia as the slope of the Treasury yield curve. These results help validate our measure of the equity yield curve.

If the major risk factors invest in short-duration stocks, the slope of the yield curve should predict their returns. We test this hypothesis in Panel B of Table IA.VII, which shows the results of predictive regressions. The dependent variables are the future realized one-year return to the equity risk factors and the dependent variable are the ex ante level and slope of the yield curve. We run rolling monthly regressions and use Newey-West standard errors with 18 lags. As can be seen in the leftmost column of Table IA.VII, the slope of the yield curve predicts future returns to the duration factor. When the yield

[8]We consider this approach instead of looking at the 10-year minus 3-month spread because we want the duration of the short-leg portfolios to mimic each other as much as possible.

curve is more downward-sloping, short-duration stocks have relatively higher returns and the duration factor thus has higher returns. The effect is statistically significant. The level of the yield curve does not predict the return to the duration factor. Similarly, we find that the slope of the yield curve negatively predicts the return to the value, profit, investment, low-risk, and payout factors, although the effect is insignificant for value and investment. The R^2 ranges from 0.09 to 0.19. The regressions also include the slope of the bond yield curve, but this is insignificant when controlling for the equity yield curve.

We next test whether the equity yield curve predicts the return to the market portfolio. All else equal, a higher level of the equity yield curve should predict a higher return to the market portfolio over the long run. In addition, if the equity yield curve is more upward-sloping, it suggests that this return is expected to be earned in the more distant future rather than the near future.[9] Accordingly, we expect a higher level to predict higher returns and a more upward-sloping curve to predict lower returns over a short horizon (less than five years).

The results in Panel C of Table IA.VII are consistent with this conjecture: a higher yield curve predicts higher returns and a more upward-sloping yield curve predicts lower returns. The effect is strongest, and statistically significant, for the four- and five-year horizons. The R^2 is as high as 42% for the five-year return. The slope of the bond yield curve also predicts returns, but it does so with the opposite sign. This reflects the well-known result in the bond literature that the slope of the bond yield curve predicts the bond term premium. Since the market is a long-duration claim, the bond term premium should carry over to the equity risk premium, which means the slope of the bond term structure should predict the equity risk premium positively.

In conclusion, the valuation ratios on duration-sorted portfolios constitute an equity yield curve. The slope of this yield curve is strongly correlated with the slope of the Treasury yield curve outside a high-inflation period centered around the 1980s. In addition, it intuitively helps predict the return to individual risk factors and the timing of the return to the market portfolio.

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[9] Gormsen (2021) discusses the effect of the slope of the equity yield curve on the return to the market portfolio.

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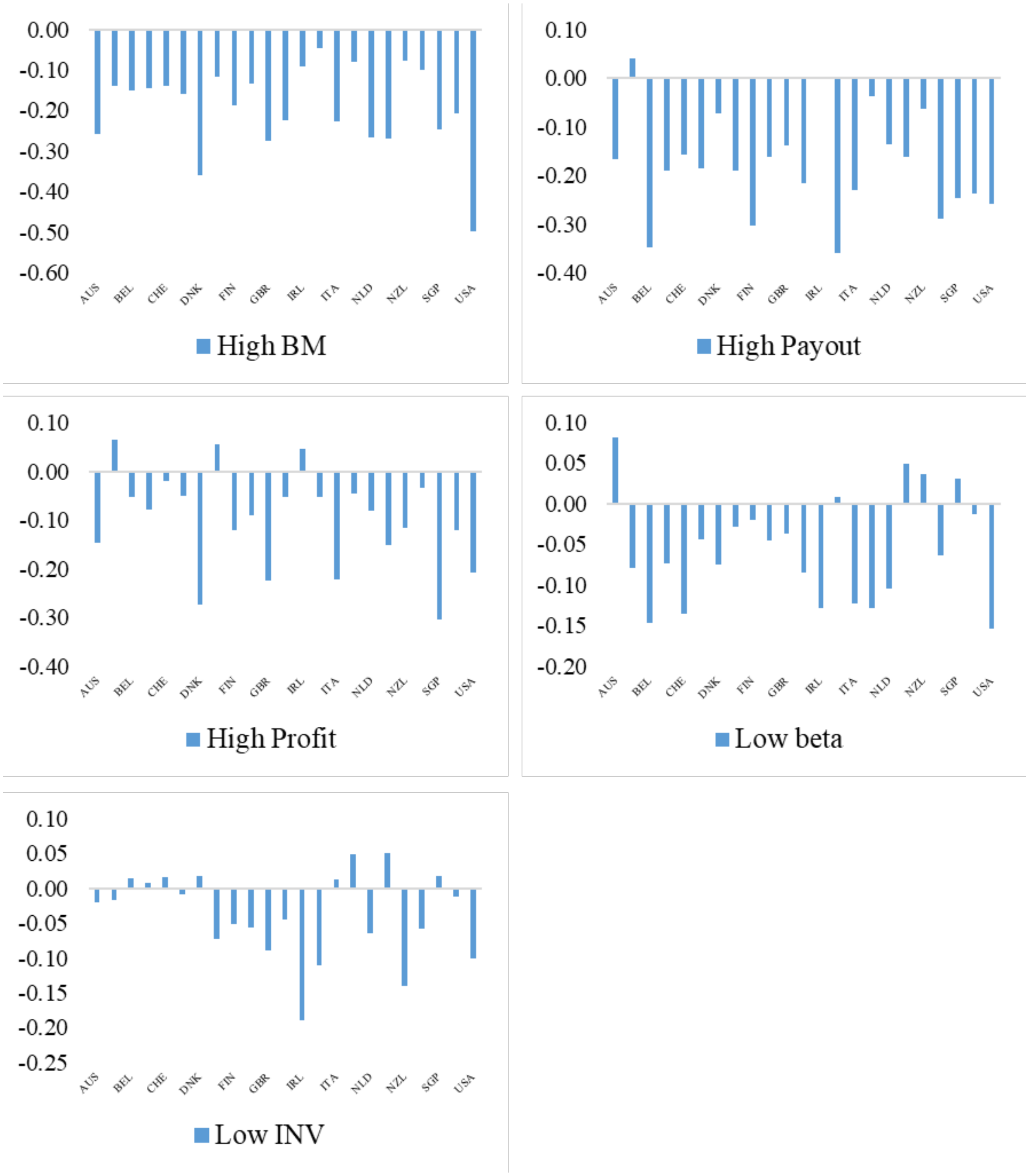

Figure IA.1. Loadings of expected growth rates on characteristics that predict returns: global evidence.

This figure shows the loading of expected growth rates on characteristics that predict returns. In each country, we regress the expected growth rates on the below characteristics in multivariate panel regressions. In almost all cases, the characteristics that predict high returns also predict low expected growth.

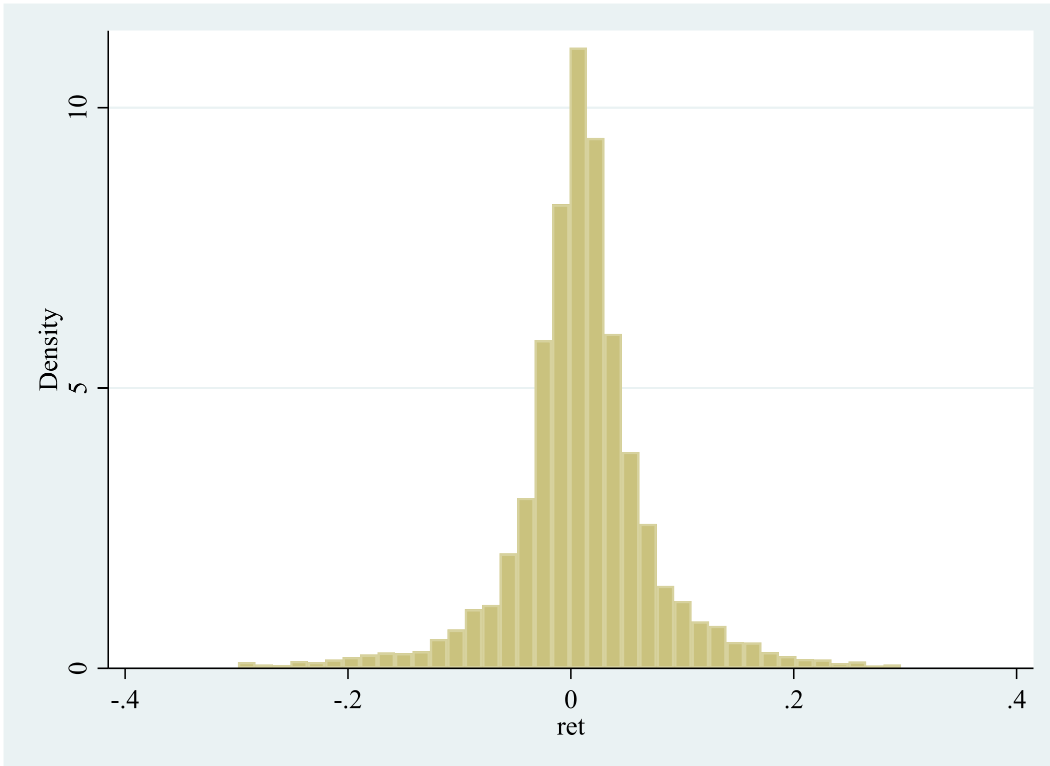

Figure IA.2. Histogram of realized monthly returns on dividend strips.
This figure shows a histogram of monthly realized returns on single-stock dividend futures. The figure excludes all observations for which monthly returns are zero. The sample is 2010 to 2019.

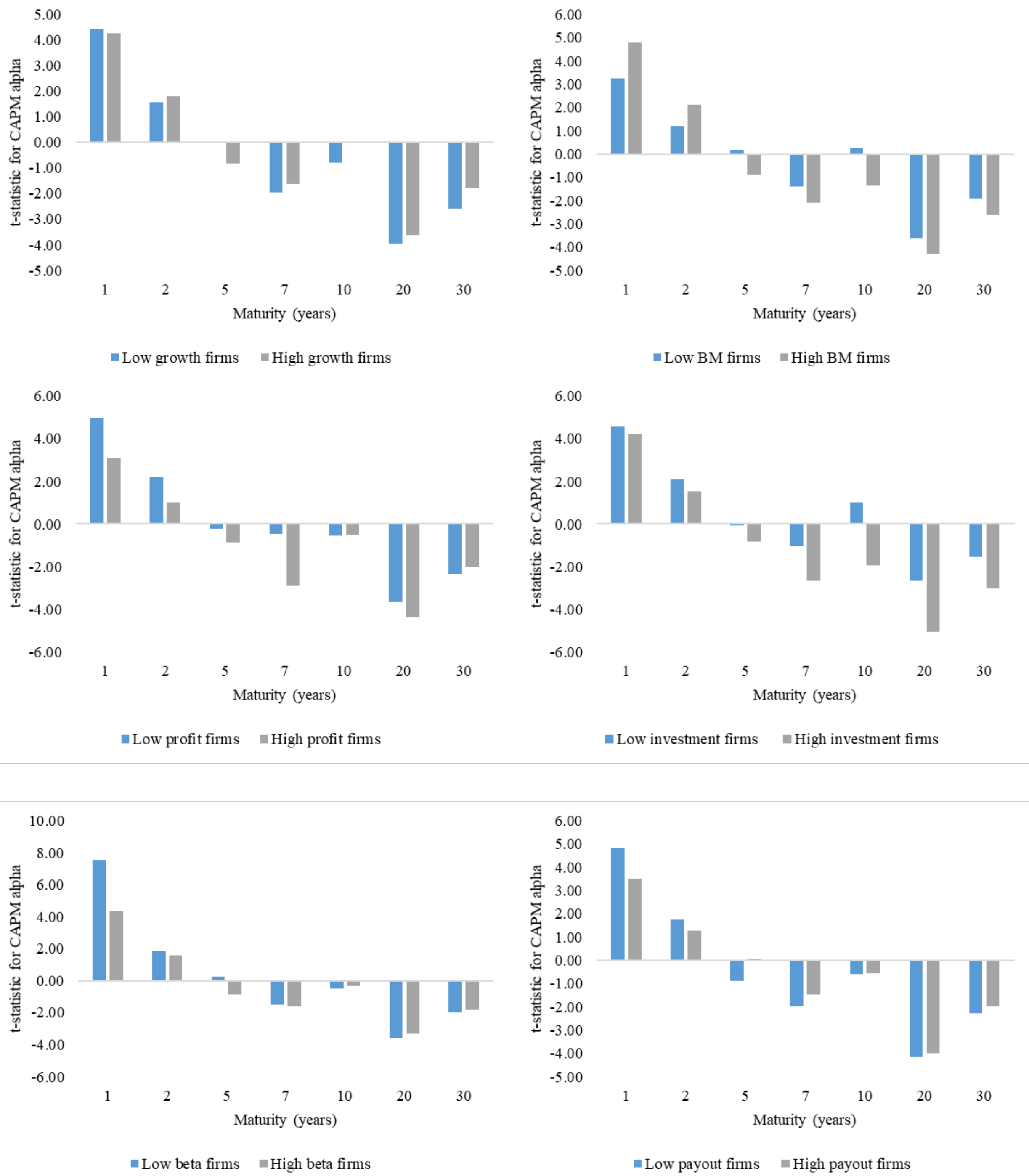

Figure IA.3. Risk-adjusted returns to corporate bond portfolios.
This figure reports t-statistics for CAPM alphas for corporate bond portfolios. We sort firms into two groups based on the median firm characteristic. Within each group, we sort all outstanding corporate bonds into portfolios based on maturity. Portfolio weights are equal-weighted and rebalanced monthly. We calculate CAPM alpha as the intercept in a time-series regression of monthly excess portfolio returns on the excess market returns. Excess returns are calculated as returns in excess of a Treasury claim with the same maturity. The market return is the equal-weighted return across all bonds. The sorting is such that the two-year portfolio, for instance, contains all bonds with maturity between one and two years. The sample is U.S. firms from 2002 to 2016.

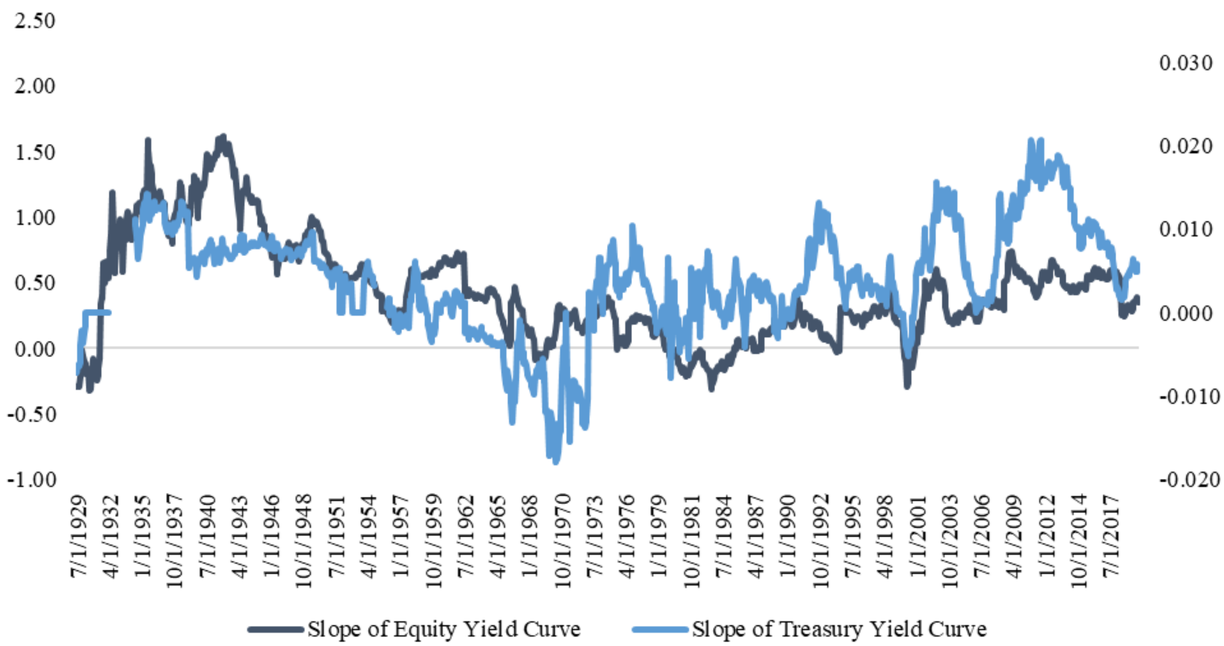

Figure IA.4. The slopes of the equity and treasury yield curves.
This figure shows the time series of the slope of the equity yield curve and the slope of the Treasury yield curve. The slope of the equity yield curve is the log book-to-market ratio of the long leg of the duration portfolio minus the log book-to-market ratio of the short leg of the duration factor. The slope of the Treasury yield curve is difference between the long- and short-duration U.S. Treasuries. The equity yield curve is measured on the left y-axis and the Treasury yield curve is on the right-hand side.

Table IA.I
Replicating Chen (2017) without Micro-Cap

This table reports the growth rate for value-sorted portfolios calculated following the method in Chen (2017). Panel A reports the results in the modern sample and the full sample including all firms. Panel B reports results excluding micro-cap (the smallest 20% of firms). Growth firms always grow faster in the modern sample, and they also grow faster in the full sample when excluding micro-cap.

Growth Rates of Portfolios Sorted on Book-to-Market Ratios

Panel A: Replication of original study including all stocks

	Modern Sample					Full Sample				
	(growth) 1	2	3	4	(value) 5	(growth) 1	2	3	4	(value) 5
5 years	4%	1%	2%	1%	-1%	3%	2%	2%	3%	5%
10 years	4%	2%	1%	1%	1%	3%	2%	2%	2%	3%
15 years	5%	3%	2%	2%	1%	4%	2%	2%	3%	3%

Panel B: Excluding micro-cap (smallest 20%)

	Modern Sample					Full Sample				
	(growth) 1	2	3	4	(value) 5	(growth) 1	2	3	4	(value) 5
5 years	4%	2%	1%	1%	-1%	3%	2%	1%	2%	2%
10 years	4%	3%	1%	1%	1%	3%	2%	1%	1%	2%
15 years	5%	4%	2%	2%	1%	4%	2%	2%	2%	2%

Table IA.II
Spanning Regressions

This table reports the results of spanning regressions with the duration factor on the left-hand side in the Fama and French (1993) and (2015) model. The CAPM alpha is the intercept in a regression of the risk factor on the excess return to the market portfolio. We report *t*-statistics in parentheses under parameter estimates and statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. The U.S. sample is from 1963 to 2018 and the global sample is from 1990 to 2018.

	U.S.		Global	
	DUR	DUR	DUR	DUR
Alpha	0.26***	0.08**	0.27***	0.04
	(4.84)	(1.97)	(4.39)	(0.96)
Market	-0.30***	-0.23***	-0.29***	-0.18***
	(23.15)	(-21.25)	(-20.57)	(-13.94)
SMB	-0.22***	-0.19***	-0.13***	-0.00
	(12.45)	(-11.5)	(-4.16)	(-0.24)
HML	0.6***	0.39***	0.56***	0.26
	(34.13)	(18.43)	(20.61)	(8.65)
CMA		0.62***		0.52***
		(19.73)		(13.01)
RMW		0.19***		0.42***
		(8.43)		(10.57)
R^2	0.80	0.88	0.75	0.86
# of observations	666	666	342	342

Table IA.III
Expected Return and Alpha on Single Stock Dividend Futures: Liquidity Controls

This table reports results from panel regressions with expected returns and alphas to single-stock dividend futures as dependent variables. We calculate expected returns as the expected yield-to-maturity using expected dividends per share from the IBES database. Alphas are expected returns minus beta times a market risk premium of 5%. Regressions are annual using end-of-December prices. See Appendix for details on how we calculate expected return and betas. In the equations below, *t, i,* and *m* denote the time, firm, and maturity of the strip at time *t* (measured in years). The data are from 2010 to 2019. Standard errors reported in parentheses are two-way clustered as specified in the table. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1.

Expected returns: $E_t\left[r_{t+m}^{i,m}\right] = \left(\frac{E_t[D_{t+m}^i]}{f_t^{i,m}}\right)^{1/m}$

CAPM alphas: $\alpha_{t+m}^{i,m} = E_t\left[r_{t+m}^{i,m}\right] - \beta_M^{i,m} \times 5\%$

Dependent variable	Expected ret	CAPM alpha	Expected ret	CAPM alpha	Expected ret	CAPM alpha
2-year dummy	-0.00	-0.01*	-0.00	-0.02**	-0.01	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
3-year dummy	-0.00	-0.03***	-0.01	-0.03***	-0.01	-0.03***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
4-year dummy	-0.02***	-0.05***	-0.03***	-0.05***	-0.02***	-0.05***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
Volume	-0.01	-0.00			0.07**	0.05
	(0.02)	(0.02)			(0.02)	(0.03)
Notional			-0.04**	-0.02*	-0.09***	-0.07**
			(0.01)	(0.01)	(0.02)	(0.02)
Observations	0.09***	0.09***	0.11***	0.10***	0.11***	0.10***
R-squared	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fixed effect						
Cluster	1,236	1,236	1,236	1,236	1,236	1,236
Weight	0.10	0.10	0.12	0.11	0.15	0.13

Table IA.IV

Expected Return and Alpha on Single Stock Dividend Futures: Firm-level Fixed Effects

This table reports results from panel regressions with expected returns and alphas to single-stock dividend futures as dependent variables. We calculate expected returns as the expected yield-to-maturity using expected dividends per share from the IBES database. Alphas are expected returns minus beta times a market risk premium of 5%. Regressions are annual using end-of-December prices. See Appendix for details on how we calculate expected return and betas. The cash-flow duration characteristic is standardized by the cross-sectional standard deviation. In the equations below, *t, i,* and *m* denote the time, firm, and maturity of the strip at time *t* (measured in years). The data are from 2010 to 2019. Standard errors reported in parentheses are two-way clustered as specified in the table. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1.

Expected returns: $E_t\left[r_{t+m}^{i,m}\right] = \left(\frac{E_t[D_{t+m}^{i}]}{f_t^{i,m}}\right)^{1/m}$

CAPM alphas: $\alpha_{t+m}^{i,m} = E_t\left[r_{t+m}^{i,m}\right] - \beta_M^{i,m} \times 5\%$

Dependent variable	Expected ret	Expected ret	Expected ret	CAPM alpha	CAPM alpha	CAPM beta
2-year dummy		0.00	-0.00	-0.01**	-0.01**	0.46***
		(0.01)	(0.00)	(0.01)	(0.01)	(0.12)
3-year dummy		-0.00	-0.00	-0.03***	-0.03***	0.82***
		(0.00)	(0.00)	(0.01)	(0.01)	(0.11)
4-year dummy		-0.01	-0.01	-0.03***	-0.03***	0.78***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.14)
CAPM beta of strip ($\beta^{i,m}$)	0.00		0.00			
	(0.00)		(0.00)			
CAPM beta of firm (β^{i})	0.02		0.02			
	(0.03)		(0.03)			
Cash-flow duration of firm	-0.00		-0.00	-0.00	-0.01	
(higher = shorter duration)	(0.01)		(0.01)	(0.01)	(0.01)	
Observations	1,219	1,229	1,219	1,229	1,229	1,702
R-squared	0.31	0.31	0.31	0.34	0.34	0.58
Fixed effect	Date/ Firm	Date/ Firm	Date/ Firm	Date/ Firm	Date/ Firm	Date/Firm
Cluster	Date/Firm	Date/Firm	Date/Firm	Date/Firm	Date/Firm	Date/Firm
Weight	None	None	None	None	Notional	None

Table IA.V

Theory: Equity Risk Factors in a Model with a Downward Sloping Equity Term Structure

This table show the CAPM alpha and duration of equity risk factors in the model. The CAPM alpha is the intercept in a regression of the return to the risk factor on the market portfolio. The duration measures the difference in the duration of the long and short legs of the factor. The duration of the long and the short legs is the equal-weighted average of the firms in the portfolio. The duration of an individual firm is the value-weighted years-to-maturity of the firm's expected cash flows over the subsequent 25 years. The table shows the median estimates of 1,000 simulations of 700 quarters of data. Alphas are in monthly percent.

	HML	RMW	CMA	Low Risk	DUR
Long leg:	High B/M	High profit	Low investment	Low beta	High duration
Short leg:	Low B/M	Low profit	High investment	High beta	Low duration
CAPM alpha	0.22	0.58	0.42	0.38	-0.60
Duration (years)	-3.5	-14.2	-7.5	-5.7	14.6

Table IA.VI
Explaining CAPM Anomalies with the Duration Factor

This table studies the performance of 25 CAPM anomalies in our three-factor model. The three factors are the market portfolio, our duration portfolio, and our small-minus-big portfolio. The table reports the three-factor alpha and its *p*-value implied by the usual *t*-test for insignificance. The table also reports the cutoff for a 5% false discovery rate under the Benjamini and Hochberg (1995) procedure. We mark anomalies that are significant under a 5% false discovery rate by **. The sample is U.S. firms from 1963-2015.

Anomaly	Alpha	*p*-value for three-factor alpha	Cutoff under a 5% false discovery rate
Net operating assets	-0.29**	0.0000	0.0020
Operating accruals	-0.26**	0.0002	0.0040
Lagged turnover	0.24**	0.0011	0.0060
Investment	-0.19**	0.0039	0.0080
Sales to price	0.29**	0.0062	0.0100
Earnings to price	-0.17**	0.0108	0.0120
Total assets	0.14	0.0175	0.0140
Capital turnover	-0.16	0.0267	0.0160
Capital turnover	-0.12	0.0309	0.0180
Maximum return	0.23	0.0533	0.0200
Idiosyncratic volatility	0.14	0.0547	0.0220
Rel to high	0.15	0.0567	0.0240
Changein PPE	-0.14	0.0628	0.0260
Adjusted book to market	0.14	0.0632	0.0280
Net operating assets	-0.07	0.3146	0.0300
Net operating assets	-0.06	0.4165	0.0320
Tobins Q	-0.09	0.4227	0.0340
Bid ask spread	-0.07	0.4277	0.0360
Sales to price	-0.06	0.4385	0.0380
Assets to market cap	-0.07	0.4761	0.0400
Bid ask spread	-0.07	0.4803	0.0420
Earnings to price	0.06	0.4908	0.0440
Maximum return	0.03	0.5680	0.0460
Asset to market cap	0.06	0.6183	0.0480
Free CF	0.01	0.8792	0.0500

Table IA.VII
The Equity Yield Curve

Panel A reports the results of regressions of the slope of the equity yield curve onto the slope of the bond yield curve. Panel B and C report results of predictive regressions. We regress the future realized returns of different risk factors on the ex ante level and slope of the equity yield curve. The level is the equal weighted log book-to-market ratio of the four subportfolios in the duration factor, and the slope is the average log book-to-market ratio of the long leg of the two long-duration portfolios in the duration factor minus the average log book-to-market ratio of the two short-duration portfolios in the duration factor. In Panel B, we run monthly regressions of annualized returns. In Panel C, we run monthly regressions with varying holding horizon. We report *t*-statistics based on Newey-West standard errors in parentheses under parameter estimates and statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Equity and bond yield curves

	Dependent variable: slope of equity yield curve			
Sample period:	Full sample	1929-1974	1974-1995	1995-2018
Slope of bond yield curve	28.44***	47.77***	12.53**	20.25***
	(5.22)	(9.50)	(2.11)	(4.38)
Adjusted-R^2	0.22	0.63	0.09	0.44
# of observations	1086	546	252	288

Panel B: Predicting risk factors

	DUR	HML	RMW	CMA	Low Risk	Payout
Level of equity yield curve	-0.08*	0.03	-0.07*	0.02	-0.09	-0.04
	(-1.65)	(0.48)	(-1.80)	(0.42)	(-1.43)	(-1.59)
Slope of equity yield curve	-0.26***	-0.23***	-0.15***	-0.13**	-0.34***	-0.13***
	(-4.23)	(-2.83)	(-2.64)	(-2.25)	(-4.38)	(-2.62)
Slope of bond yield curve	1.22	1.74	0.98	1.29	1.24	1.10
	(0.59)	(1.18)	(0.84)	(1.14)	(0.45)	(0.59)
Adjusted-R^2	0.18	0.13	0.12	0.09	0.19	0.09
# of observations	666	666	666	666	666	666

Panel C: Predicting market returns

	MKT	MKT	MKT	MKT	MKT
Horizon	1 year	2 years	3 years	4 years	5 years
Level of equity yield curve	0.16**	0.30**	0.39**	0.59**	0.94***
	(2.49)	(2.47)	(2.17)	(2.46)	(3.18)
Slope of equity yield curve	0.10	0.00	-0.32**	-0.64***	-0.81***
	(1.38)	(-0.01)	(-2.05)	(-3.58)	(-3.37)
Slope of bond yield curve	1.55	8.85**	19.66***	30.86***	37.35***
	(0.79)	(2.21)	(4.88)	(7.00)	(4.86)
Adjusted-R^2	0.09	0.16	0.25	0.37	0.42
# of observations	666	654	642	630	618

Table IA.VIII
Model Selection Tests for the Duration Factor

This table reports the results from the Feng, Giglio, and Xiu (2020, FGX) machine-learning tests for the contribution of the duration factor in explaining the cross-section. The test assets are the same 750 portfolios used by FGX. The set of potential control factors include (i) the 150 factors used by FGX, with the exception of the two factors for which there are multiple years of missing data, and (ii) our small-minus-big factor constructed from our size-duration sorts. Each entry in the first row is a separate estimate for λ_{DUR}, the loading on the duration factor in the stochastic discount factor, estimated from a cross-sectional regression. The first column uses the FGX double-selection lasso estimator to select the control factors in the regression. The second column uses only the three Fama and French (1993) factors as controls. The third column uses all 149 control factors without any dimension reduction. Estimates are scaled to correspond to an average excess return (in bps per month) for a portfolio with a unit univariate beta with respect to the duration factor and a zero univariate beta with respect to the control factors. *t*-statistics in parentheses are calculated using FGX's inference procedure, and statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. The sample is 1976 to 2017, matching the availability of test asset and factor returns used by FGX.

Feng, Giglio, and Xiu (2020) Factor Zoo Tests for Duration Factor			
	FGX Double-Selection	FF3 Controls	No Selection, OLS
λ_{DUR} (bps)	235.3***	83.6***	331.1***
	(3.05)	(3.32)	(3.25)
# of control factors	117	3	149

Table IA.IX
Alternative Methods for Constructing Duration Characteristic

This table reports the results of factor regressions in the U.S. sample. Each factor is on six portfolios based on ex ante size and the characteristic the portfolio is sorted on. The breakpoints are the median market capitalization and the 30th and 70th percentiles of duration. Portfolio weights are value-weighted and rebalanced monthly, and the breakpoints are refreshed each June and based on NYSE firms. Each factor is long 50 cents in the two high-characteristic portfolios and short 50 cents in each of the two low-characteristic portfolios, except the SMB factor, which is long the small duration-sorted portfolios and short the large duration-sorted portfolios. Three-factor alpha is in the intercept in a regression of the given equity risk factor on the market portfolio, the duration factor, and the SMB factor. CAPM alpha is the intercept in a regression of the risk factor on the excess return to the market portfolio. We report *t*-statistics in parentheses under parameter estimates and statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1. The sample is U.S. firms from 1963 to 2019. Panel A reports results from regressions where the duration characteristics is an equal-weighted average of the profit, low-investment, low-beta, and payout characteristics. Panel B reports results from regressions in which the duration characteristics is an equal-weighted average of the book-to-market, profit, low-investment, low-beta, and payout characteristics.

Panel A: Equal-weighted average

Factor	CAPM model			Three-factor model						
	α_{CAPM}	β_{CAPM}	R^2	α_{Dur}	β_{Mkt}	β_{Smb}	β_{Dur}	R^2	LTG	*# obs*
HML	0.39***	-0.16***	0.03	-0.05	0.15***	0.36***	0.69***	0.37	-9.5%	678
	(3.75)	(-6.73)		(-0.54)	(5.58)	(10.84)	(17.67)			
RMW	0.32***	-0.11***	0.18	0.10	0.13***	-0.09***	0.46***	0.36	-5.1%	678
	(3.87)	(-5.93)		(1.40)	(6.20)	(-3.68)	(15.22)			
CMA	0.37***	-0.18***	0.15	0.07	0.04**	0.24***	0.47***	0.43	-6.7%	678
	(5.19)	(-10.87)		(1.14)	(2.00)	(10.81)	(17.81)			
BETA	0.49***	-0.73***	0.59	-0.01	-0.22***	-0.08***	0.99***	0.84	-7.9%	678
	(4.21)	(-27.87)		(-0.16)	(-10.62)	(-3.15)	(32.51)			
PAYOUT	0.26***	-0.30***	0.26	0.00	-0.05***	0.00	0.50***	0.66	-7.2%	678
	(3.86)	(-19.89)		(-0.04)	(-3.32)	(-0.01)	(22.54)			

Panel B: Including book-to-market

Factor	CAPM model			Three-factor model						
	α_{CAPM}	β_{CAPM}	R^2	α_{Three}	β_{Mkt}	β_{Smb}	β_{Dur}	R^2	LTG	*# obs*
HML	0.39***	-0.16***	0.50	-0.11	0.20***	0.31***	0.77***	0.56	-9.5%	678
	(3.75)	(-6.73)		(-1.51)	(9.30)	(11.90)	(27.25)			
RMW	0.32***	-0.11***	0.52	0.18**	0.06***	-0.17***	0.31***	0.27	-5.1%	678
	(3.87)	(-5.93)	0.00	(2.45)	(2.96)	(-6.34)	(11.06)			
CMA	0.37***	-0.18***	0.70	0.06	0.04***	0.20***	0.47***	0.52	-6.7%	678
	(5.19)	(-10.87)	0.00	(1.04)	(2.80)	(10.24)	(22.53)			
BETA	0.49***	-0.73***	0.57	0.07	-0.29***	-0.20	0.83	0.82	-7.9%	678
	(4.21)	(-27.87)		(0.93)	(-13.63)	(-7.72)	(29.59)			
PAYOUT	0.26***	-0.30***	0.52	0.04	-0.08***	-0.06	0.42	0.64	-7.2%	678
	(3.86)	(-19.89)		(0.72)	(-5.56)	(-3.29)	(21.22)			

Table IA.X

Expected CAPM Alpha for Single-Stock Dividend Futures (Winsorized Betas)

This table reports the expected average CAPM alpha for portfolios of dividend strips on different firms. At the end of December, we assign all dividend strips to a long- or short-duration portfolio based on the cash-flow duration of the underlying firm. Firms are categorized as having long (short) duration if the cash-flow duration is above (below) the median of all firms on the exchange in which the firm is listed. We then calculate a pooled average CAPM alpha for all strips of a given maturity in a given portfolio. Betas are winsorized by maturity at the 5% level. Standard errors reported below the estimates are clustered by firm and date. See Appendix for details on how we calculate CAPM alphas. The data are from 2010 to 2019.

	Maturity of Strip				
	1 year	2 year	3 year	4 year	Average
Short-duration firms	0.081	0.071	0.050	0.053	0.069
	(0.026)	(0.022)	(0.014)	(0.0099)	(0.019)
Long-duration firms	0.083	0.067	0.047	0.027	0.064
	(0.0088)	(0.0078)	(0.0075)	(0.0070)	(0.0062)
Average across firms	0.082	0.068	0.048	0.030	
	(0.012)	(0.010)	(0.0075)	(0.0069)	

Table IA.XI
Expected Return and Alpha on Single-Stock Dividend Futures (Winsorized Betas)

This table reports results from panel regressions with expected returns and alphas to single-stock dividend futures as dependent variables. We calculate expected returns as the expected yield-to-maturity using expected dividends per share from the IBES database. Alphas are expected returns minus beta times a market risk premium of 5%. Betas are winsorized by maturity at the 5% level. Regressions are annual using end-of-December prices. See Appendix for details on how we calculate expected return and betas. The cash-flow duration characteristic is standardized by the cross-sectional standard deviation. In the equations below, *t, i,* and *m* denote the time, firm, and maturity of the strip at time *t* (measured in years). The data are from 2010 to 2019. Standard errors reported in parentheses are two-way clustered as specified in the table. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1

Expected returns: $E_t\left[r_{t+m}^{i,m}\right] = \left(\frac{E_t[D_{t+m}^{i}]}{f_t^{i,m}}\right)^{1/m}$

CAPM alphas: $\alpha_{t+m}^{i,m} = E_t\left[r_{t+m}^{i,m}\right] - \beta_{maturity}^{i,m} \times 5\%$

Dependent variable	Expected ret	Expected ret	Expected ret	CAPM alpha	CAPM alpha	CAPM beta
2-year dummy		-0.00	-0.00	-0.02	-0.02*	0.55*
		(0.01)	(0.01)	(0.01)	(0.01)	(0.29)
3-year dummy		-0.00	-0.01	-0.04***	-0.04***	1.32***
		(0.00)	(0.00)	(0.01)	(0.01)	(0.27)
4-year dummy		-0.02***	-0.02***	-0.05***	-0.05***	1.14***
		(0.00)	(0.00)	(0.01)	(0.01)	(0.32)
CAPM beta of strip ($\beta^{i,m}$)	0.00***		0.00***			
	(0.00)		(0.00)			
CAPM beta of firm (β^{i})	0.04**		0.04**			1.76**
	(0.02)		(0.02)			(0.58)
Cash-flow duration of firm	-0.00		-0.00	0.01	0.00	
(higher = shorter duration)	(0.00)		(0.00)	(0.01)	(0.01)	
Observations	1,226	1,236	1,226	1,236	1,236	1,699
R-squared	0.13	0.10	0.14	0.10	0.12	0.20
Fixed effect	Date/Cur	Date/Cur	Date/Cur	Date/Cur	Date/Cur	Date/Cur
Cluster	Date/Firm	Date/Firm	Date/Firm	Date/Firm	Date/Firm	Date/Firm
Weight	None	None	None	None	Notional	None

Table IA.XII
Realized Return and Alpha on the Annual Horizon for Single-Stock Dividend Futures (Winsorized Betas)

This table reports results from panel regressions with realized return and alphas to single-stock dividend futures as dependent variables. A single stock dividend future is the price for the dividend that is paid out in a given year by a given firm. We calculate realized annual returns for each calendar year. We calculate realized alpha as the realized returns minus the product of the realized market return and the beta of the strip. The beta of the strip is estimated in first-stage regressions (see Appendix A for details). The betas are winsorized by maturity at the 5% level. The cash-flow duration characteristic is standardized by the cross-sectional standard deviation. In the equations below, *t, i,* and *m* denote the time, firm, and maturity of the strip at time *t* (measured in years). The data are from 2010 to 2019. Standard errors reported in parentheses are two-way clustered as specified in the table. Statistical significance is denoted by *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Realized returns	Realized log-returns	Realized alpha	Realized alpha	Realized log-alpha	Realized log-alpha
2-year dummy	0.0010	-0.0013	-0.041	-0.043	-0.040	-0.040
	(0.019)	(0.016)	(0.034)	(0.031)	(0.033)	(0.029)
3-year dummy	0.0027	-0.0066	-0.11	-0.11	-0.12*	-0.12*
	(0.033)	(0.029)	(0.064)	(0.064)	(0.063)	(0.064)
4-year dummy	-0.022	-0.038	-0.11*	-0.12*	-0.15*	-0.16*
	(0.035)	(0.033)	(0.056)	(0.061)	(0.074)	(0.078)
Cash-flow duration of firm	0.0062	0.011	0.033	0.035	0.040**	0.040**
(higher = shorter duration)	(0.015)	(0.013)	(0.019)	(0.020)	(0.014)	(0.014)
Observations	1,473	1,464	1,473	1,473	1,464	1,464
R-squared	0.045	0.039	0.064	0.072	0.066	0.069
Fixed effect	Date/currency	Date/currency	Date/currency	Date/currency	Date/currency	Date/currency
Cluster	Date/Firm	Date/Firm	Date/Firm	Date/Firm	Date/Firm	Date/Firm
Weight	None	None	None	Notional	None	Notional