EQUITY TERM STRUCTURES WITHOUT DIVIDEND STRIPS DATA

Stefano Giglio[1], Bryan Kelly[2], Serhiy Kozak[3]

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[1]Yale SOM and NBER
[2]Yale SOM, NBER, and AQR
[3]University of Maryland

Motivation

The term structure of equity risk premia

- The term structure of discount rates for risky assets plays an important role in many fundamental economic contexts:
  - Pricing an asset or evaluating an investment opportunity with a specific maturity
  - Investment in climate-change mitigation (extra long maturity)

- Active area of empirical research. Two seminal approaches:
  1. Lettau and Wachter (2007): *use the C-S of equities.*
     Early literature also relied on strong parametric assumptions: Bansal et al. (2005), Hansen et al. (2008), Da (2009).

  2. Van Binsbergen et al. (2013): *use new dividend strips data.*
     Also van Binsbergen et al. (2012), van Binsbergen and Koijen (2015).

Our approach

- We use the cross-section of equities and rich dynamics:
  - Specify an empirical affine model; price all assets jointly
  - Impose discipline: pricing restrictions, state vector choice
  - Generate T-S of ER for market and 100 C-S portfolios
  - Similar to Lettau and Wachter (2007), but much richer well-disciplined SDF dynamics with emphasis on C-S of equities
- Distinct feature – rich, realistic dynamics, motivated by recent empirical AP findings:
  1. Kozak, Nagel, and Santosh (JF 2018, JFE 2019): a few dominant PCs of anomaly returns explain the C-S
  2. Haddad, Kozak, and Santosh (RFS 2020): D/Ps of PCs to predict risk prices $\rightarrow$ critical for adequately capturing SDF dynamics

Goals and findings

- Model-implied EY match yields in the literature well
  - Strip data since 2004: BMSY, BK
  - We do not use any strip data in our estimation!
- Use model to extend the term-structure data:
  - over time, back to the 1970s;
  - across maturities, e.g., 1–100 years,
  - across portfolios, e.g., small or value stocks.

Goals and findings

- Term-structure results:
    - Results of the post-2004 sample carry over to the longer sample:
        - T-S inverts in almost all of the additional recessions
        - T-S of forward discount rates is still “too flat” on average
        - Expected div. growth varies substantially over time
    - New cross-sectional results:
        - Value (growth) stocks strongly increasing (flat) T-S of ER
        - Small stocks: flat T-S of ER, large stocks: mildly increasing
        - Time-series: small stocks’ inversion in the late 90s

- Our goal:

  – new “stylized facts” to guide and evaluate AP models

Methodology

Model: Setup

- State vector F_t:

$$\underbrace{F_{t+1}}_{k\times 1} = \underbrace{c}_{k\times 1} + \underbrace{\rho}_{k\times k} F_t + u_{t+1}, \tag{1}$$

- SDF:

$$m_{t+1} = -r_{f,t} - \frac{1}{2}\lambda_t'\Sigma\lambda_t - \lambda_t' u_{t+1}, \tag{2}$$

where $\lambda_t = \lambda + \Lambda F_t$.

- Log prices (returns):

$$\Delta p_{t+1} - r_{f,t} = \gamma_0 + \gamma_1 F_t + \gamma_2 u_{t+1}, \tag{3}$$

- Implies equity prices satisfy:

$$y_t \equiv \log\left(1 + \frac{D_{t+1}}{P_{t+1}}\right) = b_0 + b_1 F_t. \tag{4}$$

Model: State vector and restrictions

- F_t contain the market, PCs of L-S anomalies, and their D/Ps:

$$F = [r_M, r_{PC_1}, ..., r_{PC_3}, \quad y_M, y_{PC_1}, ..., y_{PC_3}]'$$

- Restrictions:
  1. Only shocks to returns are priced
  2. Only y_t predict F_{t+1}, that is,

$$\Lambda = \begin{bmatrix} 0_{4\times4} & \tilde{\Lambda}_{4\times4} \\ 0_{4\times4} & 0_{4\times4} \end{bmatrix} \quad \Rightarrow \quad \rho = \begin{bmatrix} 0_{4\times4} & \rho_{r,y} \\ 0_{4\times4} & \rho_{y,y} \end{bmatrix}.$$

Model: Other portfolios

- Prices and returns of other well-diversified portfolios are measured with error:

$$y_t = b_0 + b_1 F_t + \epsilon_t$$
$$r_{t+1} - r_{f,t} = \beta_0 + \beta_1 F_t + \beta_2 u_{t+1} + \varepsilon_{t+1}.$$

- Only b_0, b_1, β_2 need to be estimated (easy); β_0, β_1 pinned down by no-arbitrage

Model: Recap

- Affine model
- State vector contains 4 PCs of anomaly ret. and their D/Ps
- Dynamics and restrictions motivated by:
  1. Kozak, Nagel, and Santosh (JF 2018, JFE 2019):
     - No near-arbitrage $\Rightarrow$ only a few large PCs show up as factors
     - Reduces C-S of many factors to a few dominant PC-factors
  2. Haddad, Kozak, and Santosh (RFS 2020):
     - Bound cond. SR $\Rightarrow$ only dominant PCs should be *predictable*
     - Forecast $E_{t-1}[R_t]$ on PC-factors using own D/Ps
     - Important source of SDF time-variation
- These choices are critical for realistic SDF dynamics

Model: Estimation

- Joint GMM estimation with these moments:
  - State space shocks: $u_{t+1} \perp F_{y,t}$
  - Portfolio returns: $r_{t+1} \perp \{F_{y,t}, u_{t+1}\}$
  - Yields: $y_t \perp F_{y,t}$
- Asymptotic GMM standard errors
  - Spectral covariance matrix with 12 lags
  - Standard errors of everything via the Delta method

Dividends strips prices and equity yields

- Dividend strips prices:

$$\frac{P_t^{(n)}}{P_t} = \mathrm{E}^{\mathbb{Q}}\left[\frac{D_{t+n}}{P_t}\right] = e^{a_{n,1}+d_{n,1}F_t} - e^{a_{n,2}+d_{n,2}F_t},$$

  where $a_{n,\cdot}, d_{n,\cdot}$ are given by recursions.

- Equity yields (no approximations):

$$e_{t,n} = \frac{1}{n}\log\left(\frac{D_t}{P_t^{(n)}}\right) = \frac{1}{n}\left[\log\left(e^{y_{t+n}} - 1\right) - \log\left(\frac{P_t^{(n)}}{P_t}\right)\right].$$

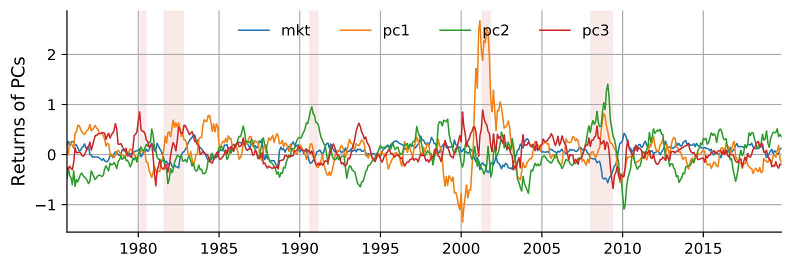
- Similarly, can compute:
  - Realized and expected HPR returns on dividend strips
  - Decomposition into hold-to-maturity (HTM) exp. returns and expected real div. growth rates at each maturity
  - Volatility, Sharpe ratios, forward equity yields, etc.

Results

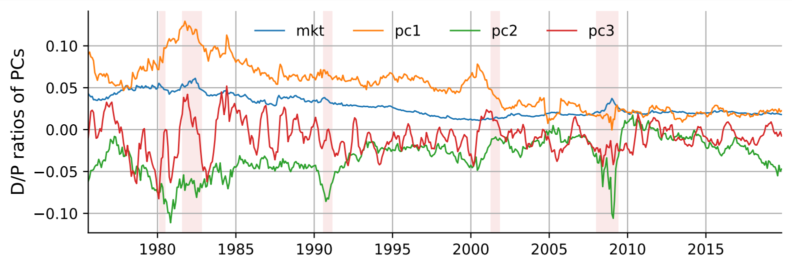
Data

- Stocks sorted into 3 portfolios based on 50 characteristics from Kozak (2019), one at a time
- Joint GMM estimation, asymptotic GMM s.e.
- All results orthogonal to the bond term-structure
- Monthly sample from September 1974 to December 2019. Annual horizon.

PC-factor returns predictability and predictors' dynamics



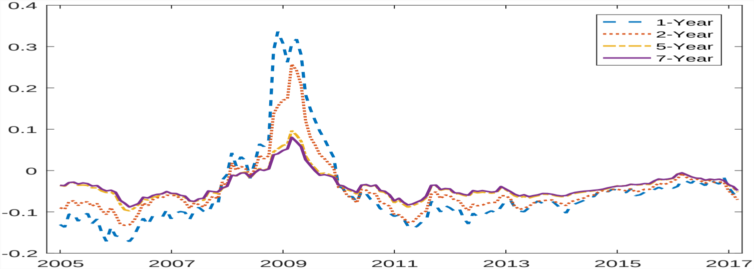
(a) PC factor returns



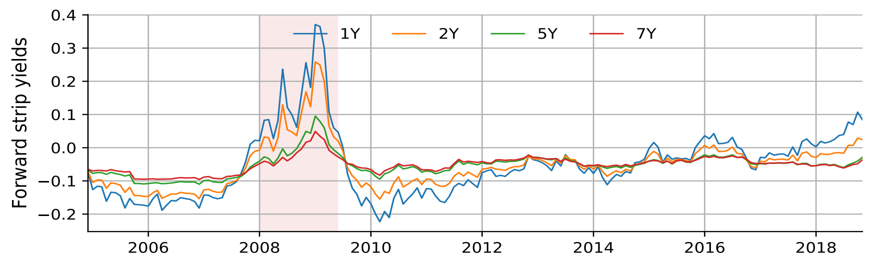
(b) D/P ratios of SDF factors

Fit to traded S&P 500 futures

Time-series of equity yields: our model vs. strips data (2005–)

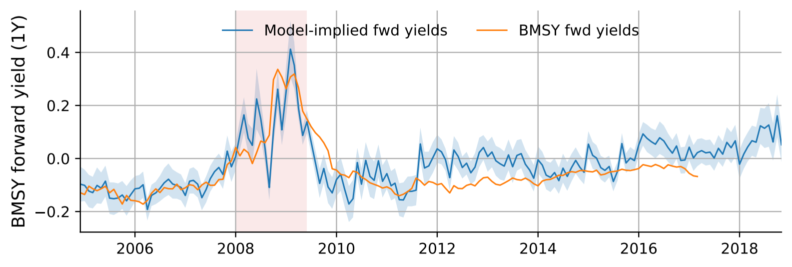


(a) Bansal, Miller, Song, Yaron (2018): equity fwd yields for S&P 500

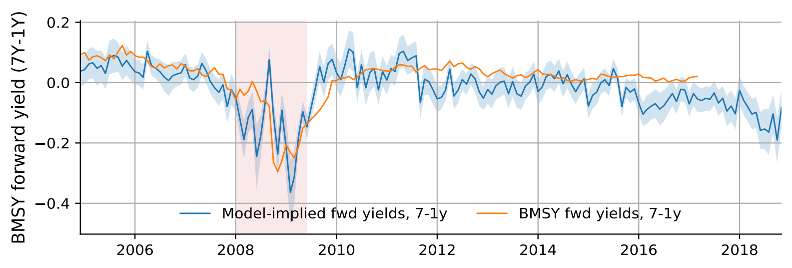


(b) Model-implied fwd equity yields for large stocks (approx. S&P 500)

Model-implied fwd equity yields vs. fwd equity yield data

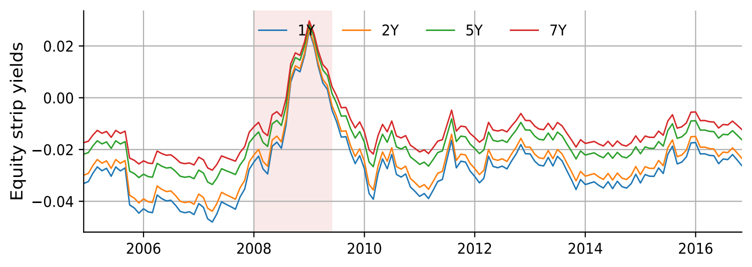


(a) 1-year

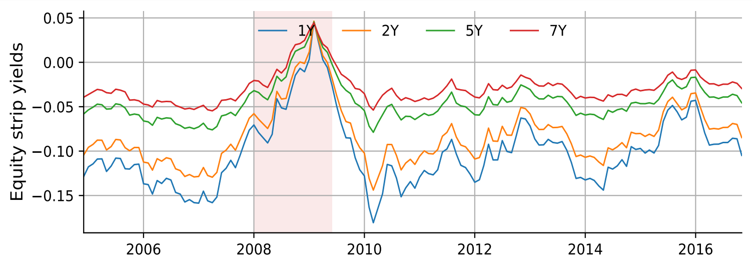


(b) 7y-1y

Dynamics of benchmark-implied equity strip yields

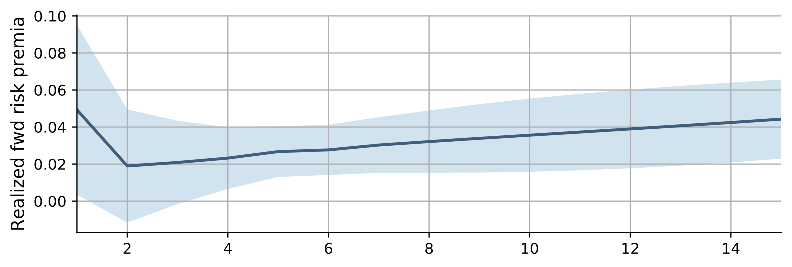


(a) CAPM

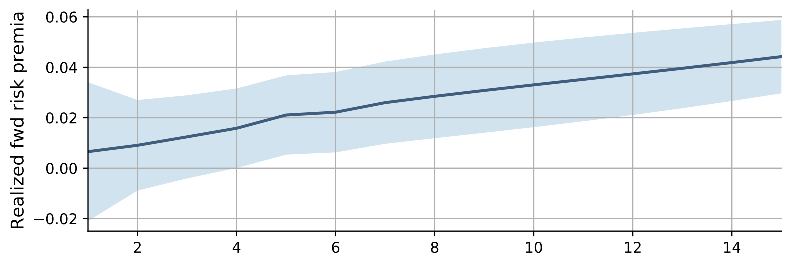


(b) FF 5-factor + Momentum

Estimated term structure of forward strip risk premia

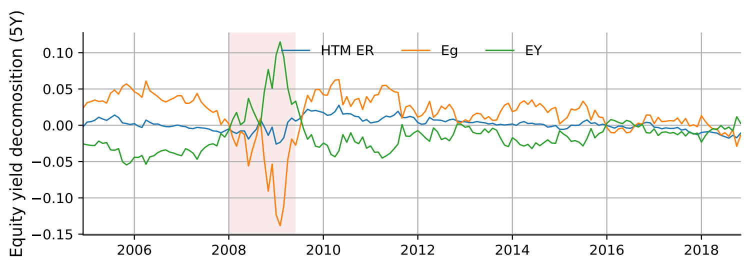


(a) BMSY sample (2005–2019)

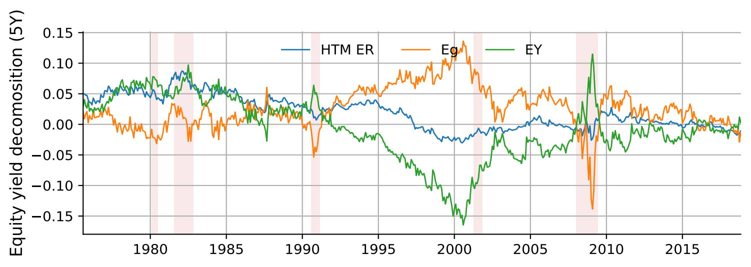


(b) Full sample (1975–2019)

Decomposition of the 5-year equity yield

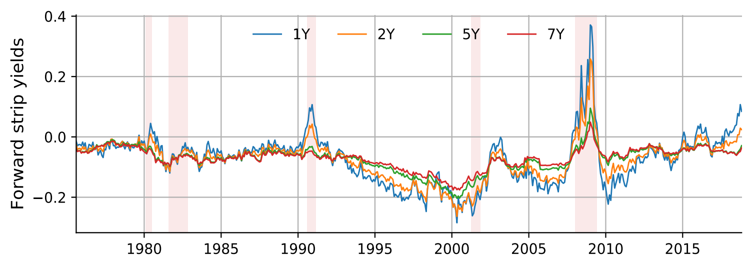


(a) BMSY sample (2005–2019)

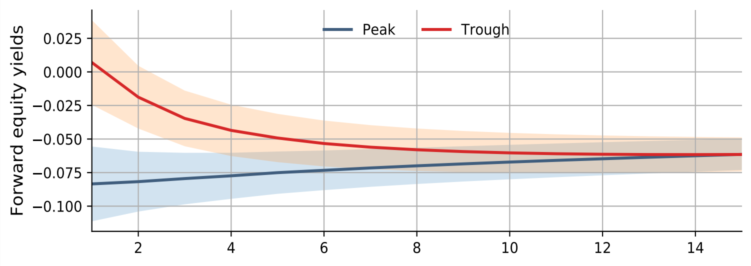


(b) Full sample (1975–2019)

Model-implied fwd equity yields (FEY)



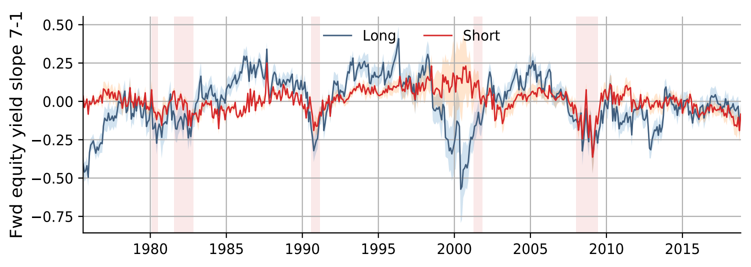
(a) FEY dynamics for selected maturities



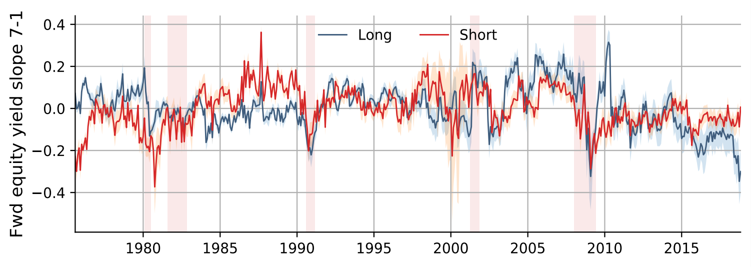
(b) FEY conditional on NBER recessions

Cross-sectional results

Slope 7-1 of forward equity yields

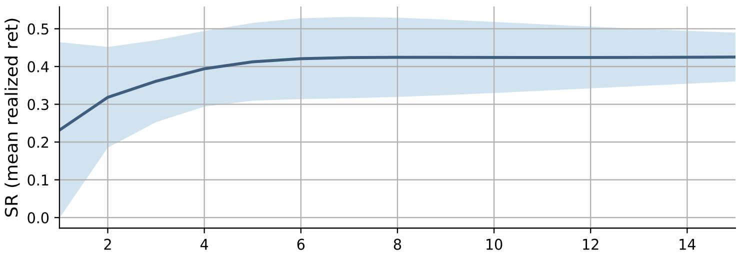


(a) Small and large stocks

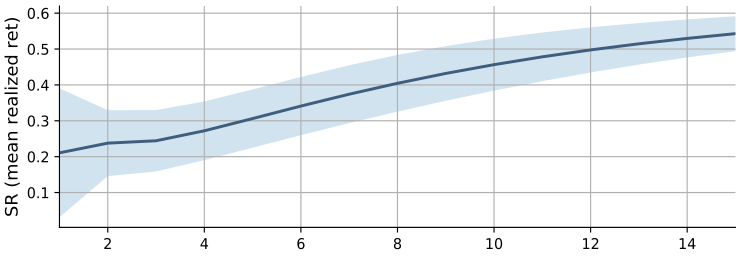


(b) Value and growth stocks

Sharpe ratios: value vs. growth

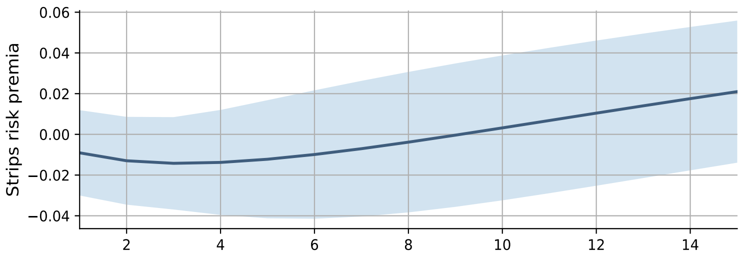


(a) Growth stocks

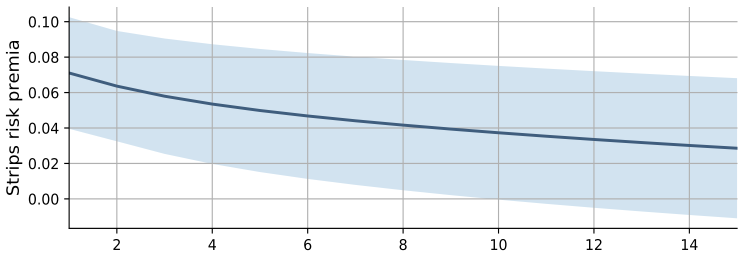


(b) Value stocks

Expected returns on long-short portfolios

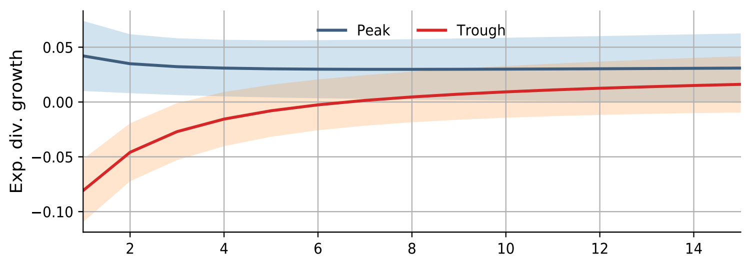


(a) Value-growth

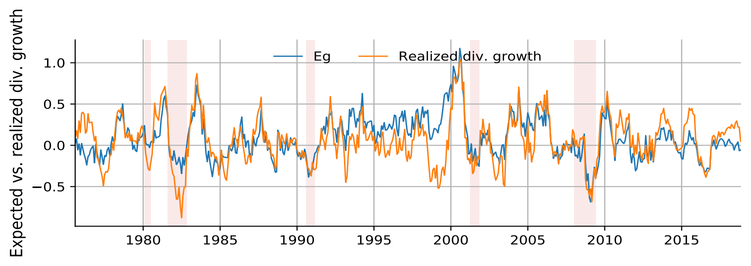


(b) Small-big

Implied expected dividend growth

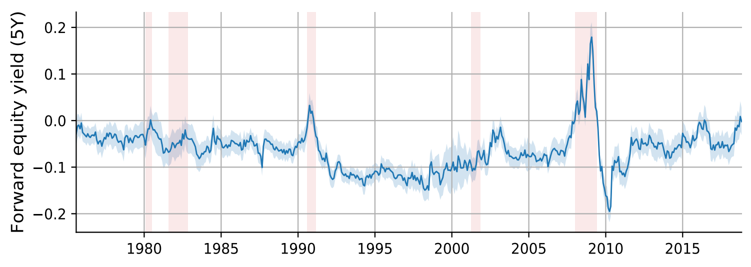


(a) Large stocks (S&P 500)

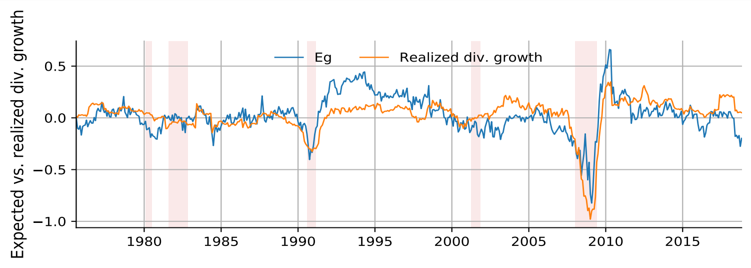


(b) Momentum stocks

High leverage stocks: yields and expected div. growth



(a) FEY



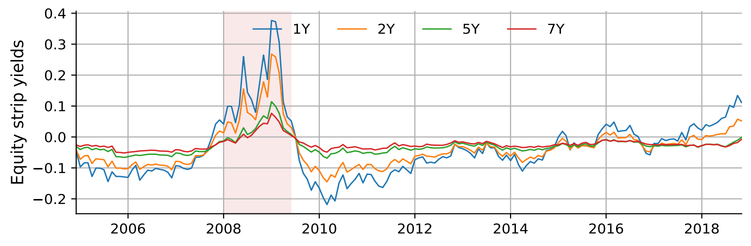
(b) Expected dividend growth

Conclusions

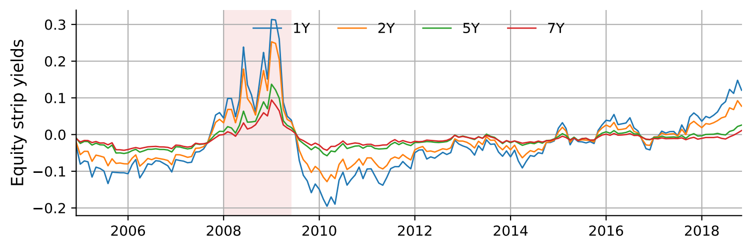
- New methodology to study equity price dynamics and the term structure of risk premia
- We produce new "stylized facts":
  - The T-S and C-S behavior of dividend term structures
  - Similar to VAR by Sims (1980) we provide new moments for evaluation and guidance of AP models
  - Our synthetic strips extend the term-structure data:
    - over time, back to the 1970s;
    - across maturities, e.g., 1–100 years,
    - across portfolios, e.g., small or value stocks.
- Potential applications:
  - Test C-S implications of models: Hansen et al. (2008), Belo (2010); Kogan and Papanikolaou (2013, 2014)
  - Evaluate investments of different horizon, e.g., PE.

Appendix: Out-of-sample analysis

IS and OOS dynamics of model-implied yields in BMSY sample



(a) In-sample

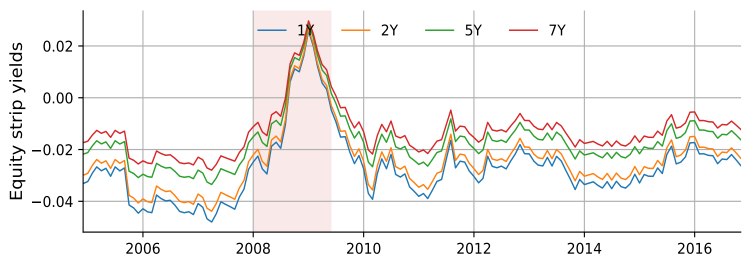


(b) Out-of-sample

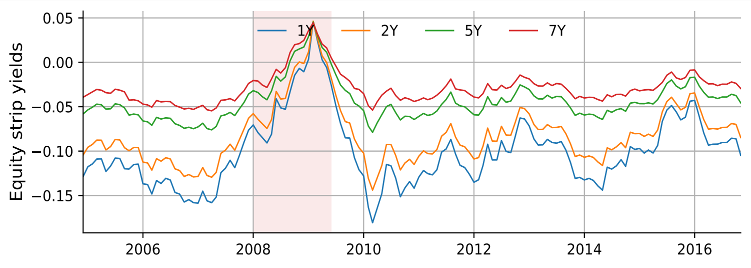
Figure 4: Model parameters are estimated in the 1975–2004 sample and held constant throughout the rest of the sample.

Appendix: Counterfactual analysis

Dynamics of benchmark-implied equity strip yields

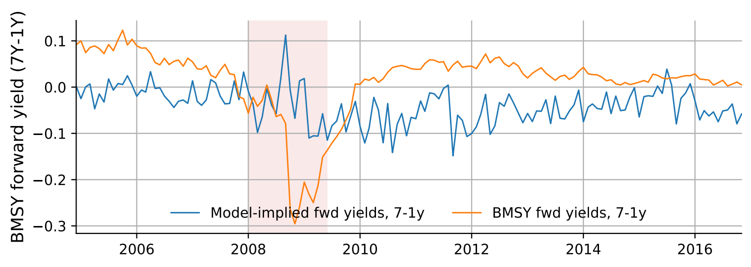


(a) CAPM

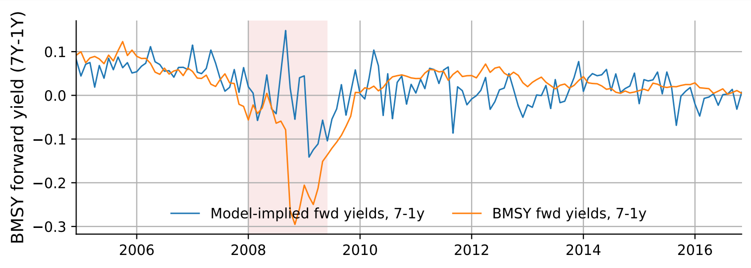


(b) FF 5-factor + Momentum

Benchmark-implied FEY vs. data



(a) CAPM



(b) FF 5-factor + Momentum

Appendix: Motivation

Characterizing the SDF: From stocks to managed portfolios

- Project the "true" SDF onto the space of excess returns,

$$M_t = 1 - b'_{i,t-1}\left(R_{i,t} - \mathrm{E}[R_{i,t}]\right),$$

- Let $b_{i,t-1}$ be linear in C-S characteristics $X_{i,t-1}$:

$$b_{i,t-1} = X_{i,t-1}\gamma,$$

  - compresses N coeffs for each stock to K coeffs for each char.
  - $\gamma \equiv \gamma_{t-1}$ contains only remaining time-varying *aggregate* info

- Plug in:

$$M_t = 1 - \gamma'_{t-1}\left(F_t - \mathrm{E}[F_t]\right),$$

  - where $F_t = X'_{t-1}R_t$ is a vector of characteristics-based factors
  - i.e., we can equivalently represent SDF in terms of managed portfolios

Characterizing the SDF: Two results

1. Kozak, Nagel, and Santosh (JF 2018, JFE 2019):
    - Absence of near-arbitrage requires only a few large PCs show up as factors
    - Reduces the C-S of potentially hundreds of factors to a few dominant PC-factors
2. Haddad, Kozak, and Santosh (RFS 2020):
    - Bound cond. SR: only dominant PCs should be predictable
    - Forecast $\mathrm{E}_{t-1}[R_t]$ on PC-factors using own valuation ratios
    - PC exp. returns are highly predictable, more than agg. market
    - Important source of SDF time-variation!
    - recover γ_{t-1} and prices of risk $\Rightarrow$ SDF

$\rightarrow$ We estimate an empirical model motivated and consistent with these findings

References

Bansal, R., R. F. Dittmar, and C. T. Lundblad (2005). Consumption, dividends, and the cross-section of equity returns. *Journal of Finance 60(4)*, 1639–1672.

Belo, F. (2010). Production-based measures of risk for asset pricing. *Journal of Monetary Economics 57*(2), 146–163.

Da, Z. (2009). Cash flow, consumption risk, and the cross-section of stock returns. *The Journal of Finance*, 923–956.

Haddad, V., S. Kozak, and S. Santosh (2019). Factor timing. *Available at SSRN 2945667*.

Hansen, L. P., J. C. Heaton, and N. Li (2008). Consumption strikes back? measuring long-run risk. *Journal of Political Economy 116(2)*, 260–302.

Kogan, L. and D. Papanikolaou (2013). Firm characteristics and stock returns: The role of investment-specific shocks. *The Review of Financial Studies 26*(11), 2718–2759.

Kogan, L. and D. Papanikolaou (2014). Growth opportunities, technology shocks, and asset prices. *The journal of finance 69*(2), 675–718.

Kozak, S. (2019). Kernel trick for the cross section. *Available at SSRN 3307895*.

Kozak, S., S. Nagel, and S. Santosh (2018). Interpreting factor models. *The Journal of Finance 73*(3), 1183–1223.

Lettau, M. and J. A. Wachter (2007). Why is long-horizon equity less risky? a duration-based explanation of the value premium. *Journal of Finance 62*(1), 55–92.

Van Binsbergen, J., W. Hueskes, R. Koijen, and E. Vrugt (2013). Equity yields. *Journal of Financial Economics 110*(3), 503–519.

van Binsbergen, J. H., M. W. Brandt, and R. Koijen (2012). On the timing and pricing of dividends. *American Economic Review 102*, 1596–1618.

van Binsbergen, J. H. and R. S. Koijen (2015). The term structure of returns: Facts and theory. Working paper.