Quantitative Asset Management

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Lecture 6: Return Predictability

1. Overview: discount rates
   John H Cochrane (2011, JF Presidential address)
2. Forecasting stock returns
   John Y Campbell and Samuel B Thompson (RFS, 2007)
   Ivo Welch and Amit Goyal (2007, RFS)
3. Forecasting stock returns under economic constraints
   Davide Pettenuzzo, Allan Timmermann, and Rossen Valkanov (JFE, 2014)

Return Predictability

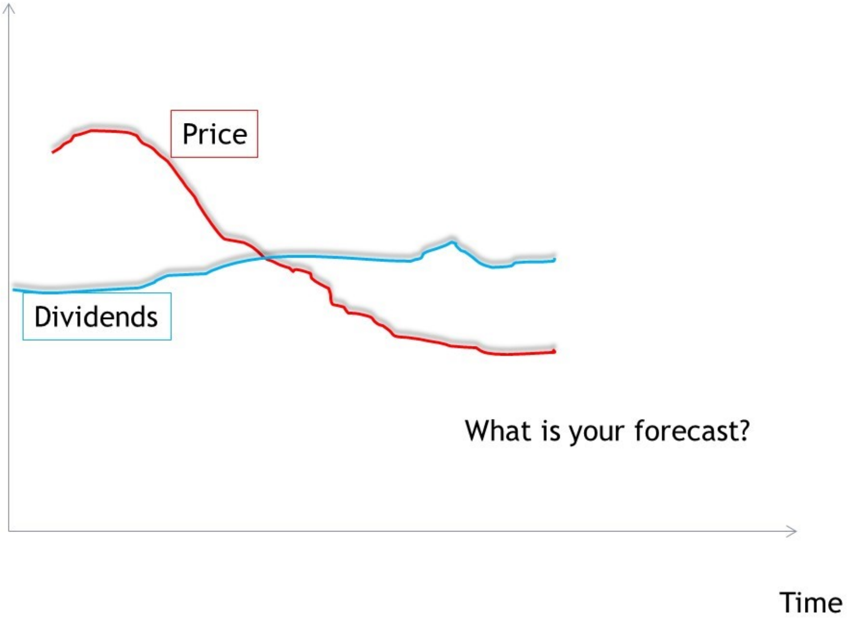
- We are now going to take a closer look at stock return predictability.
- Returns are said to be predictable whenever investors have any information in their information set today that helps to predict future returns.
- This could include past returns, but it also could include other information (such as the dividend yield, interest rates, bond yields, etc..)
- Whenever returns are predictable, this can be exploited by timing the market. Just rebalancing is no longer the optimal strategy.

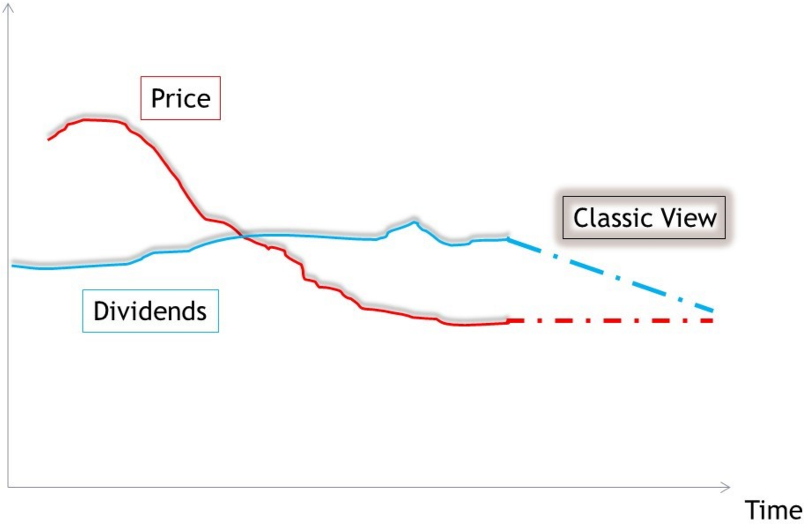
Return Predictability: Chasing Yields works!

1. Stocks: high dividend yields predict high returns
2. Treasury bonds: high yields predict high returns (rather than higher short term interest rates)
3. Corporate bonds: high yields predict high returns (rather than defaults)
4. Currencies: high yields predict high returns
5. Real Estate: high yields predict high returns (not low rental prices)

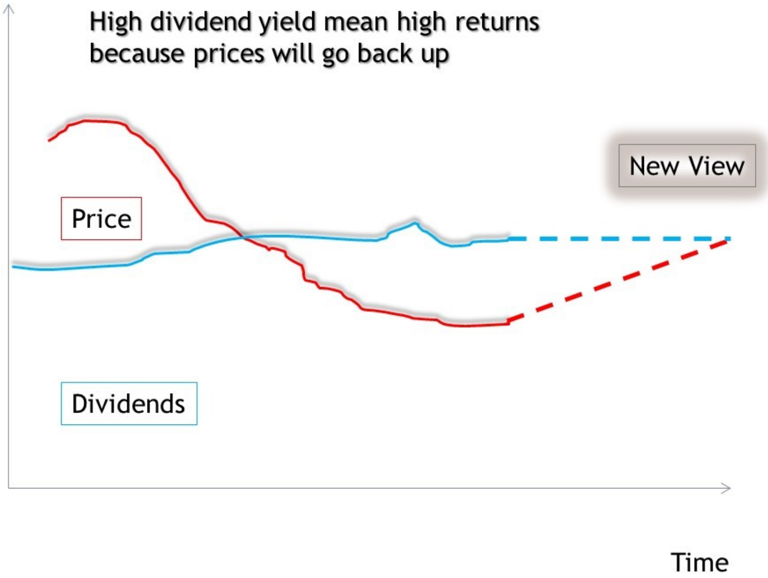
1. Stock Markets

- High dividend yields or low price/dividend ratios predict high returns
  - Prices will go up in order to bring the price/dividend ratio back up to its long run steady-state value
  - Cash flows will not adjust
- This creates room for market timing: when price/dividend ratios are low, we can expect high stock returns over the next (say) 5 years


Price
Dividends
What is your forecast?
Time

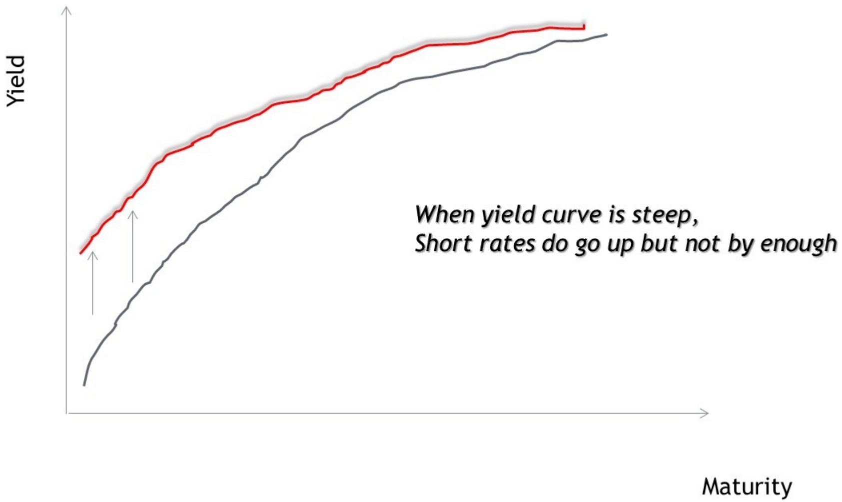


Low subsequent dividend growth pushes the dividend yield Back down


High dividend yield mean high returns
because prices will go back up
New View
Price
Dividends
Time

2. Bond Markets

- High Treasury bond yields predict high returns
  - When the slope of the yield curve is steep, short rates do tend to increase subsequently but not by enough
  - As a result, bond returns are predictable because the higher yield more than offsets the capital losses
- This creates room for market timing: when the slope of the yield curve is steep, we can expect high bond returns over the next (say) 1 year


Yield
When yield curve is steep,
Short rates do go up but not by enough
Maturity

3. Corporate Bond Markets

- Corporate bond credit spreads (difference between corporate and comparable Treasury bond): predict returns
- Corporate bond credit spreads are higher than default probabilities
- Increase in credit spread mostly signal higher expected returns, not higher default probability

4. Currency Markets

- High interest rates do predict high returns on a currency
- High interest rates currencies do not tend to depreciate
- If anything they subsequently appreciate

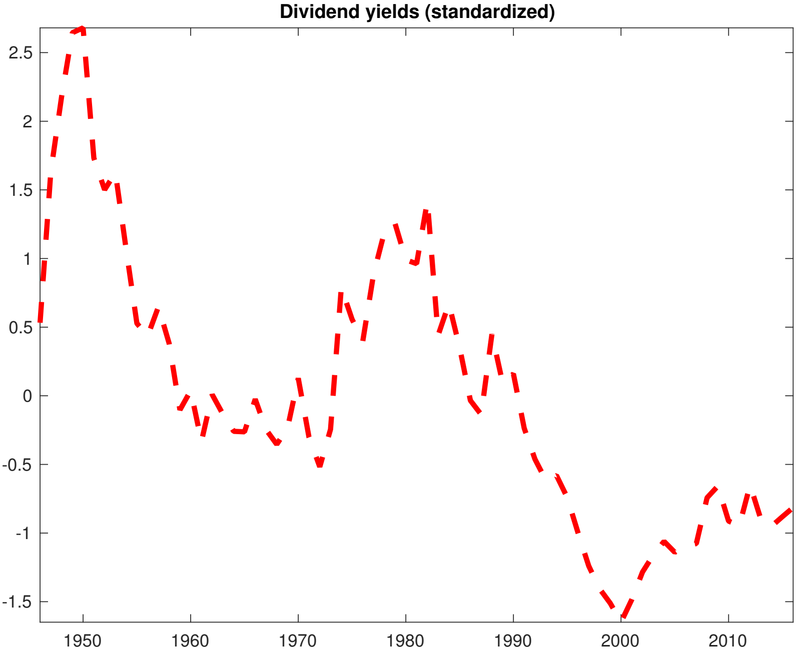
5. Housing Markets

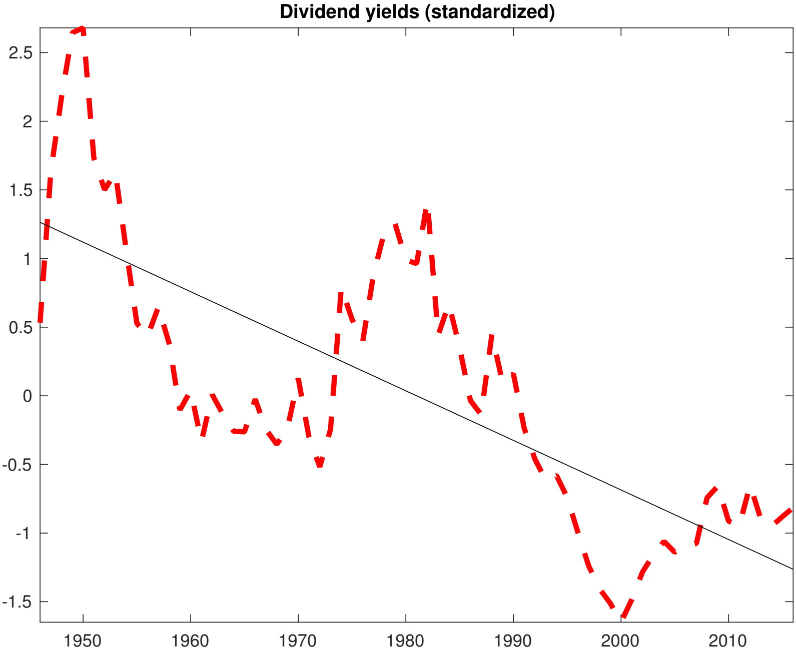
- High price/rent ratios signal mostly low returns, rather than high rents in the future
- After 2005, price/rent ratios came down because house prices came down, not because rents increased

Stock Return Predictability

Stock Return Predictability

- Let's take a look at the dividend/yield data for the U.S.
- We'll use the dividend yield for the VW-CRSP Index (includes Amex, NYSE and NASDAQ) available on CRSP
- This index essentially includes all publicly traded stocks


Dividend yields (standardized)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
1950
1960
1970
1980
1990
2000
2010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2
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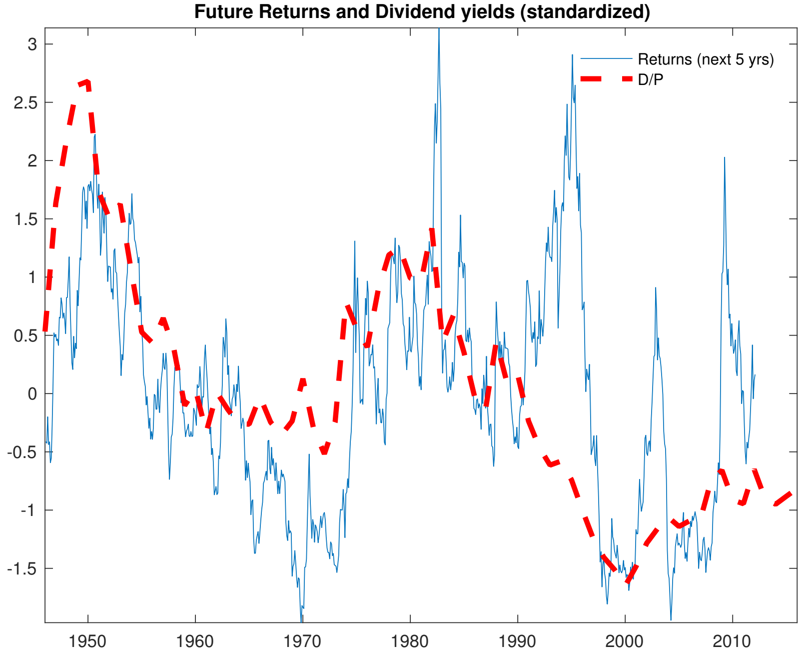
2010

Dividend Yield

- The U.S. dividend yield has been trending down secularly since the early 80's
  - This may be partly due to changes in the payout behavior of U.S. corporations (switch to repurchases etc.)
- But it turns out there is a tight link between the dividend yield and future returns
- We compare the dividend yield $\log \frac{d_t}{p_t}$ and returns in the future $\log R_{t \to t+k} - \log R^f_{t \to t+k}$
- Do you know how to compute dividend yield from cum- and ex- divided returns?


Future Returns and Dividend yields (standardized)
Returns (next 5 yrs)
D/P
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
1950
1960
1970
1980
1990
2000
2010

Regression Results

$$R^e_{t\rightarrow t+k} = a + b \times \frac{D_t}{P_t} + \varepsilon_{t+k}$$

Horizon k	b	$t(b)$	R^2	$\sigma[E_t(R^e)]$	$\frac{\sigma[E_t(R^e)]}{E(R^e)}$
1 year	3.8	(2.6)	0.09	5.46	0.76
5 years	20.6	(3.4)	0.28	29.3	0.62

Table 1 from Cochrane (2010)

Interpretation

- Large effects of dividend yield on returns:
  - One percentage point increase in dividend yield forecasts near four percentage points in return
- 5.46 percent of variation from fitted value!
  - This is comparable to the equity premium
- Note that the R^2 increases with the forecasting horizon:
  - Very hard to predict stock returns between now and the same time tomorrow
  - Much easier to predict stock returns between now and the same time 5 years from now.

Discount vs. Cash Flow

Time-series facts

- Dividend yields forecast returns with economically large coefficients
- Cambell-Shiller decomposition:

$$dp_t \approx \sum_{j=1}^{k} \rho^{j-1} r_{t+j} - \sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j} + \rho^k dp_{t+k}$$

  - dividend yields vary because of cash-flow or discount rate?
  - turns out that high prices relative to dividends entirely forecast low returns

Discount vs. Cash Flow

- Regressions

$$\sum_{j=1}^{k} \rho^{j-1} r_{t+j} = a_r + b_r^k dp_t + \varepsilon_{t+k}^r$$

$$\sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j} = a_{\Delta d} + b_{\Delta d}^k dp_t + \varepsilon_{t+k}^{\Delta d}$$

$$\rho^k dp_{t+k} = a_{dp} + b_{dp}^k dp_t + \varepsilon_{t+k}^{dp}$$

- Cambell-Shiller decomposition implies

$$1 \approx b_r^k - b_{\Delta d}^k + b_{dp}^k$$

Regression Results—Table 2 from Cochrane (2010)

	Coefficient		
Method and Horizon	$b_r^{(k)}$	$b^{(k)}{}_{\Delta d}$	$\rho^k b^{(k)}{}_{dp}$
Direct regression , $k = 15$	**1.01**	**−0.11**	**−0.11**
Implied by VAR, $k = 15$	**1.05**	**0.27**	**0.22**
VAR, $k = \infty$	**1.35**	**0.35**	**0.00**

- pd ratio volatility: variation in expected returns!
- Old Paradigm: high prices relative to dividends forecast higher dividend growth
- In the data, we have the opposite!
- New Paradigm: high prices relative to dividends forecast lower returns

All price-dividend ratio volatility corresponds to variation in expected returns. None corresponds to variation in expected dividend growth, and none to "rational bubbles."

Chasing High Yields Works!

- If you regress future Treasury **bond returns** on the slope of the yield curve, you'll also find evidence of return predictability
- If you regress future **currency returns** on interest rate differences (=difference between forward rate and spot rate) between countries, you'll also find evidence of return predictability
- If you regress future **commodity returns** on the difference between the forward price and the spot price, you'll also find evidence of return predictability
- These strategies are referred to as 'carry' trades

What's carry?

- Carry is the expected return on an investment when the price does not change:
  1. Currencies: interest rate difference
  2. Commodities: difference between spot price and forward price
  3. Stocks: Dividend yield (roughly)
  4. Bonds: Slope of the yield curve
- Carry predicts returns (see 'Carry' by Koijen, Moskowitz, Pedersen and Vrugt) in all of these markets

New Paradigm

- CAPM is a poor measure of risk
- Stock Returns are predictable
- Bond Returns are predictable
- Currency Returns are predictable
- Professional managers do outperform passive portfolios and simple indexes after adjusting for market beta

Improving Forecasting Regressions

Campbell & Thompson (2008, RFS)

- Response to Welch and Goyal (2007)
  - WG: poor predictability of the equity premium
  - WG: better to just use average returns as predictor
- Stock returns are predictable
- Many of the predictability regressions can serious econometric issues

  e.g. Stambaugh (1999) bias: if dp ratio follow an AR(1) then we get biased estimations

  There are several papers trying to fix this and other issues
- Another issue: out-of-sample performance
  - We want a model that generate good out-of-sample forecasts

Campbell & Thompson (2008, RFS)

Key contribution:

- Agrees with GW: unimpressive in-sample results and poor out-of-sample performance
- Restricted regressions perform considerably better than unrestricted ones
  - Truncation based on sign:

    $$\max\{R_t^{forecast}, 0\}$$

  - Require positive estimated slope

    $$\max\{\beta_t^{forecast}, 0\}$$

  - These improve out-of-sample R^2

Campbell & Thompson (2008, RFS)

Data

- Forecasting variables
  - valuation ratios: the dividend-price ratio, earnings-price ratio, smoothed earnings-price ratio, and book-to-market ratio
  - Smoothed measure of accounting real return on equity (ROE). This gives a measure of the total resources available to be divided between real payouts and real growth in book equity.
  - Nominal interest rates and inflation: the short-term interest rate, the long-term bond yield, the term spread between long- and short-term treasury yields, the default spread between corporate and treasury bond yields, and the lagged rate of inflation.
  - Equity share of new issues proposed by Baker and Wurgler (2000) and the consumption-wealth ratio of Lettau and Ludvigson (2001).

Campbell & Thompson (2008, RFS)

- Monthly data and predict simple monthly or annual stock returns on the S&P 500 Index
- Truncation based on sign:

$$\max\{R_t^{forecast}, 0\}$$

- Require positive estimated slope

$$\max\{\beta_t^{forecast}, 0\}$$

- These improve out-of-sample R^2

Campbell & Thompson (2008, RFS)

Table 1: Excess return prediction with regression constraints

	Sample Begin	Forecast Begin	In-Sample t-statistic	In-Sample R-squared	Out-of-Sample R-squared with Different Constraints			
					Unconstrained	Positive Slope	Pos. Forecast	Both
A: Monthly Returns								
Dividend-price ratio	1872m2	1927m1	1.25	1.13%	−0.65%	0.05%	0.07%	0.08%
Earnings-price ratio	1872m2	1927m1	2.29	0.71	0.12	0.18	0.14	0.18
Smooth earnings-price ratio	1881m2	1927m1	1.85	1.36	0.33	0.42	0.38	0.43
Book-to-market	1926m6	1946m6	1.96	0.61	−0.43	−0.43	0.00	0.00
ROE	1936m6	1956m6	0.36	0.02	−0.93	−0.06	−0.93	−0.06
T-Bill rate	1920m1	1940m1	2.44	0.86	0.52	0.51	0.57	0.55
Long-term yield	1870m1	1927m1	1.46	0.19	−0.19	−0.19	0.20	0.20
Term spread	1920m1	1940m1	2.16	0.65	0.46	0.47	0.45	0.46
Default spread	1919m1	1939m1	0.74	0.10	−0.19	−0.19	−0.19	−0.19
Inflation	1871m5	1927m1	0.39	0.06	−0.22	−0.21	−0.18	−0.17
Net equity issuance	1927m12	1947m12	1.74	0.48	0.34	0.34	0.50	0.50
Consumption-wealth ratio	1951m12	1971m12	4.57	2.60	−1.36	−1.36	0.27	0.27
B: Annual Returns								
Dividend-price ratio	1872m2	1927m1	2.69	10.8	5.53	5.53	5.63	5.63
Earnings-price ratio	1872m2	1927m1	2.84	6.78	4.93	4.93	4.94	4.94
Smooth earnings-price ratio	1881m2	1927m1	3.01	13.57	7.89	7.89	7.85	7.85
Book-to-market	1926m6	1946m6	1.98	8.26	−3.38	−3.38	1.39	1.39
ROE	1936m6	1956m6	0.35	0.32	−8.60	−0.03	−8.35	−0.03
T-Bill rate	1920m1	1940m1	1.77	4.26	5.54	5.54	7.47	7.47
Long-term yield	1870m1	1927m1	0.91	0.77	−0.15	−0.15	2.26	2.26
Term spread	1920m1	1940m1	1.72	3.10	4.79	4.79	4.74	4.74
Default spread	1919m1	1939m1	0.07	0.01	−3.81	−3.81	−3.81	−3.81
Inflation	1871m5	1927m1	0.17	0.07	−0.71	−0.71	−0.71	−0.71
Net equity issuance	1927m12	1947m12	0.54	0.35	−4.27	−4.27	−2.38	−2.38
Consumption-wealth ratio	1951m12	1971m12	3.76	19.87	−7.75	−7.75	−1.48	−1.48

Campbell & Thompson (2008, RFS)

Table 2: Excess return prediction with valuation constraints

	Sample Begin	Forecast Begin	In-Sample t-statistic	In-Sample R-squared	Out-of-Sample R-squared with Different Constraints: Unconstrained	Positive Slope, Pos. Forecast	Pos. Intercept, Bounded Slope	Fixed Coefs
A: Monthly Returns								
Dividend/price	1872m2	1927m1	1.25	1.12%	−0.66%	0.08%	0.19%	0.42%
Earnings/price	1872m2	1927m1	2.28	0.71	0.12	0.18	0.25	0.76
Smooth earnings/price	1881m2	1927m1	1.85	1.35	0.32	0.43	0.43	0.97
Dividend/price + growth	1891m2	1927m1	1.40	1.03	−0.05	0.20	0.17	0.63
Earnings/price + growth	1892m2	1927m1	1.82	0.49	−0.05	0.08	0.07	0.57
Smooth earnings/price + growth	1892m2	1927m1	2.00	1.10	0.11	0.25	0.21	0.72
Book-to-market + growth	1936m6	1956m6	1.61	0.33	−0.35	−0.34	−0.34	0.33
Dividend/price + growth − real rate	1891m5	1927m1	1.47	0.86	−0.02	0.21	0.18	0.41
Earnings/price + growth − real rate	1892m2	1927m1	1.53	0.36	0.00	0.12	0.09	0.39
Smooth earnings/price + growth − real rate	1892m2	1927m1	1.97	0.84	0.15	0.26	0.23	0.52
Book-to-market + growth − real rate	1936m6	1956m6	1.68	0.36	−0.45	−0.45	−0.42	0.24
B: Annual Returns								
Dividend/price	1872m2	1927m1	2.69	10.89	5.53	5.63	3.76	2.20
Earnings/price	1872m2	1927m1	2.84	6.78	4.93	4.94	4.34	5.87
Smooth earnings/price	1881m2	1927m1	3.01	13.57	7.89	7.85	6.44	7.99
Dividend/price + growth	1891m2	1927m1	1.77	9.30	2.49	2.99	2.67	4.35
Earnings/price + growth	1892m2	1927m1	1.42	4.44	1.69	2.11	1.80	3.89
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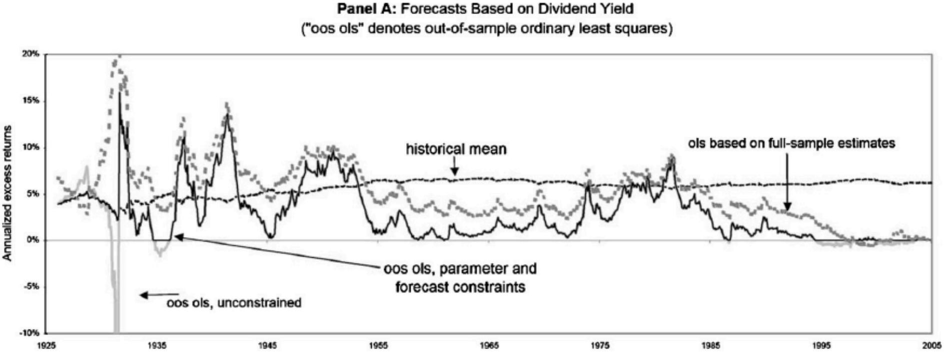
Smooth earnings/price + growth − real rate	1892m2	1927m1	1.53	7.90	3.35	3.35	3.38	3.22
Book-to-market + growth − real rate	1936m6	1956m6	2.03	5.77	−1.73	−1.12	−1.82	2.33

Campbell & Thompson (2008, RFS)



Campbell & Thompson (2008, RFS)

Relation between Sharpe Ratio and R^2

$$r_{t+1} = \mu + x_t + \varepsilon_{t+1}$$

- x_t has mean zero and variance σ_x^2
- ε_t has mean zero and variance σ_ε^2
- Assume a mean-variance investor with risk aversion γ
- Unconditional Sharpe ratio:

$$S = ?$$

- R^2 for the regression of excess return pn predictor variable

$$R^2 = ?$$

Campbell & Thompson (2008, RFS)

Relation between Sharpe Ratio and R^2

- Optimal mean-variance weight on the risky asset:

$$\alpha = ?$$

and earn an average excess return given by:

$$\mathbb{E}[\alpha r_{t+1}] = ?$$

Campbell & Thompson (2008, RFS)

Relation between Sharpe Ratio and R^2

- Optimal time-varying mean-variance weight:

$$\alpha_t = ?$$

and earn an average excess return given by:

$$\mathbb{E}[\alpha_t r_{t+1}] = ?$$

Campbell & Thompson (2008, RFS)

Relation between Sharpe Ratio and R^2

- Gain from timing the market:

$$\mathbb{E}[\alpha_t r_{t+1}] - \mathbb{E}[\alpha r_{t+1}] =?$$

- Gain from timing the market:

$$\frac{\mathbb{E}[\alpha_t r_{t+1}] - \mathbb{E}[\alpha r_{t+1}]}{\mathbb{E}[\alpha r_{t+1}]} =?$$

Takeaway

- Stock returns are predictable
- Unconstrained models perform poorly (Welch and Goyal results)
- Simple ad-hoc constraint go a long way in terms of improving out-of-sample performance
- Predictive regressions R^2 look small but it makes sense: benefit from timing the investment is roughly proportional to $\frac{R^2}{S^2}$

Further Improving Forecasting Regressions

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

- Similar idea to Campbell and Thompson (2008)
- Economically motivated constraints offer the potential to sharpen forecasts, particularly when the data are noisy and parameter uncertainty is a concern as in return prediction models.

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

- Estimations constraints:
  - Non-negative equity premia
  - Bounds on the conditional Sharpe ratio
- Bayesian approach: compute the predictive density of the equity premium subject to economic constraints
- Approach makes efficient use of the entire sequence of observations in computing the predictive density and also accounts for parameter uncertainty
- What is the difference between this approach and the one developed by Campbell and Thompson?

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Equity premium constraint

- Linear model to forecast returns:

$$r_{\tau+1} = \mu + \beta x_\tau + \varepsilon_{\tau+1}, \quad \tau = 1, \ldots, t-1,$$

$$\varepsilon_{\tau+1} \sim \mathrm{N}(0, \sigma_\varepsilon^2).$$

- Equity premium constraint:

$$\mu + \beta x_\tau \geq 0 \quad \text{for } \tau = 1, \ldots, t.$$

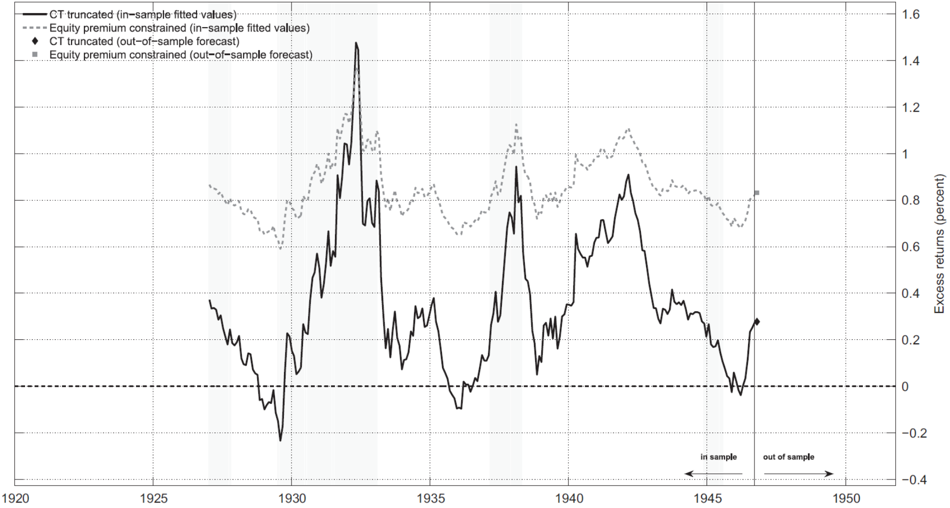
- Campbell and Thompson approach:

$$\hat{r}_{t+1|t} = \max(0, \hat{\mu}_t + \hat{\beta}_t x_t),$$

  - Ignores information about the estimation if negative EP

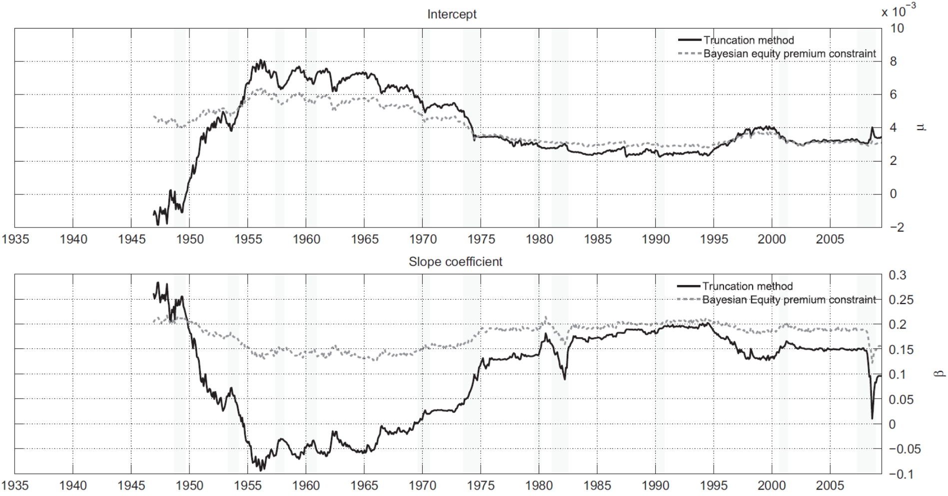
Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Equity premium forecast: one-period ahead



Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Equity premium constraint: using default yield as predictor



Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Sharpe Ratio constraint

- Linear model with time-varying volatility:

$$r_{\tau+1} = \mu + \beta x_\tau + \exp(h_{\tau+1}) u_{\tau+1},$$

  where the noise term is standard normal
- The log volatility is a random walk

$$h_{\tau+1} = h_\tau + \xi_{\tau+1}$$

  where $\xi_{\tau+1} \sim N(0, \sigma_\xi^2)$
- Sharpe ratio is given by

$$SR_{\tau+1|\tau} = \frac{\sqrt{H}(\mu + \beta x_\tau)}{\exp(h_\tau + 0.5\sigma_\xi^2)},$$

  - How to calculate this expression?
- Shape ratio bounds

$$SR^l \leq SR_{\tau+1|\tau} \leq SR^u \quad \text{for } \tau = 1, \ldots, t$$

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Sharpe Ratio constraint

- Shape ratio bounds

$$SR^l \leq SR_{\tau+1|\tau} \leq SR^u \quad \text{for } \tau = 1, \ldots, t$$

- SR should be positive
- SR around 0.5 are seen as normal
- Baseline estimation: Sharpe ratios in the unit interval

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Bayesian estimation

There are three parameters to estimate: μ, β, and σ_ξ

- Economic constraints are priors
- Parameters are seen as random variables
- Start with a prior about the parameters
- Update your parameters posteriors to get estimates
- Updating is tricky given the constraints

  Solution: simulations

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Bayesian estimation: no constraint

Prior of μ and β

$$\begin{bmatrix} \mu \\ \beta \end{bmatrix} \sim \mathrm{N}(\underline{b}, \underline{V})$$

where

$$\underline{b} = \begin{bmatrix} \overline{r}_t \\ 0 \end{bmatrix}, \quad \underline{V} = \begin{bmatrix} \underline{\psi}^2 s_{r,t}^2 & 0 \\ 0 & \underline{\psi} s_{r,t}^2 / s_{x,t}^2 \end{bmatrix}$$

$$\overline{r}_t = \frac{1}{t-1} \sum_{\tau=1}^{t-1} r_{\tau+1}, \quad s_{r,t}^2 = \frac{1}{t-2} \sum_{\tau=1}^{t-1} (r_{\tau+1} - \overline{r}_t)^2$$

$$\overline{x}_t = \frac{1}{t-1} \sum_{\tau=1}^{t-1} x_{\tau}, \quad s_{x,t}^2 = \frac{1}{t-2} \sum_{\tau=1}^{t-1} (x_{\tau} - \overline{x}_t)^2$$

$\underline{\Psi}$ controls the tightness of the prior

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Bayesian estimation: no constraint

Prior for the error precision of the return innovation:

$$\sigma_{\varepsilon}^{-2} \sim G(s_{r,t}^{-2}, \underline{v}_0(t-1))$$

The history of volatility is updated according to

$$p(h^t|\sigma_{\xi}^{-2}) = \prod_{\tau=1}^{t-1} p(h_{\tau+1}|h_{\tau}, \sigma_{\xi}^{-2})p(h_1)$$

Initial distribution of volatility

$$h_1 \sim \mathrm{N}(\ln(s_{r,t}), \underline{k}_h)$$

Prior of σ_{ξ}

$$\sigma_{\xi}^{-2} \sim G(1/\underline{k}_{\xi}, 1)$$

Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Bayesian estimation: imposing constraints

Modified priors

$$\begin{bmatrix} \mu \\ \beta \end{bmatrix} \sim \mathrm{N}(\underline{b}, \underline{V}), \quad \mu, \beta \in A_t$$

EP constraint:

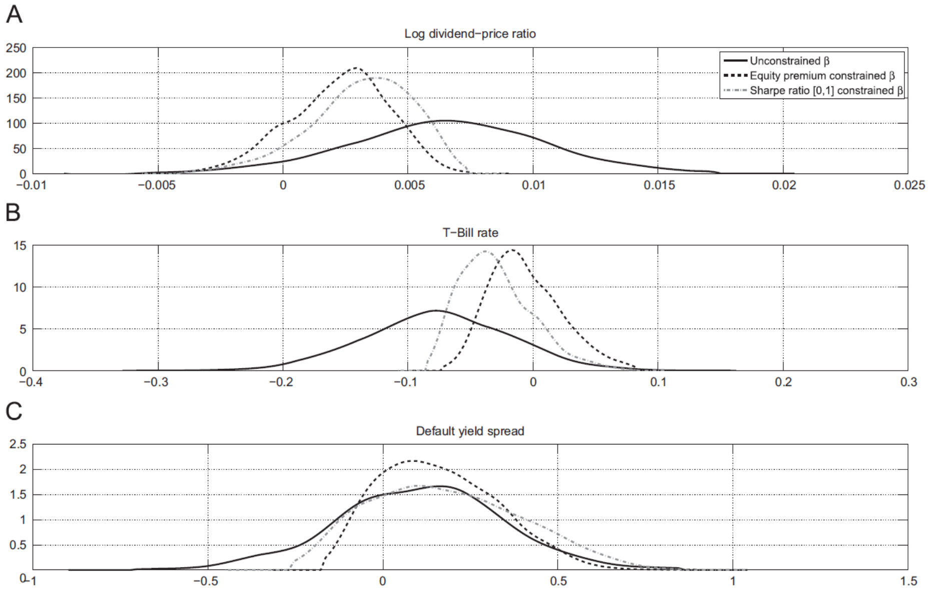
$$A_t = \{\mu + \beta x_\tau \geq 0, \tau = 1, \ldots, t\}$$

Sharpe ratio constraint

$$\tilde{A}_t = \{SR^l \leq SR_{\tau+1|\tau} \leq SR^u, \tau = 1, \ldots, t\}$$

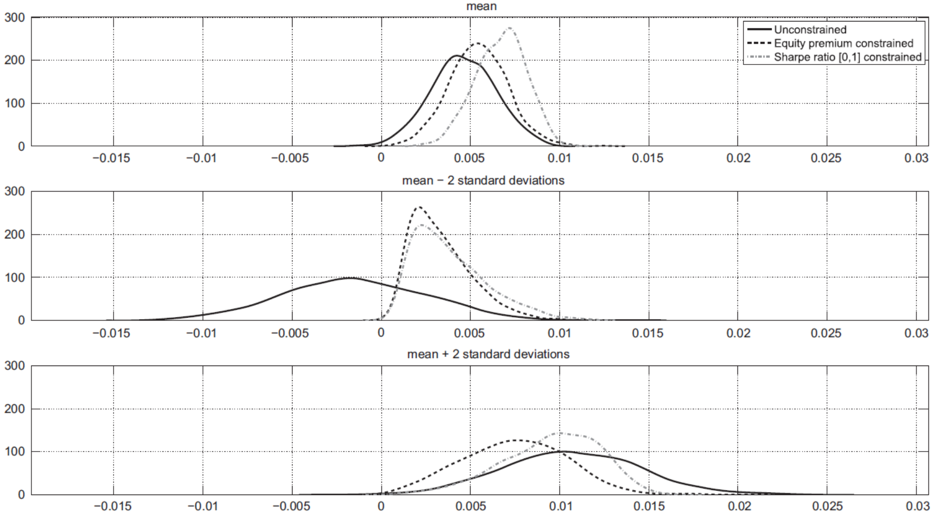
Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Posterior of slope coefficients (using data until 2010)



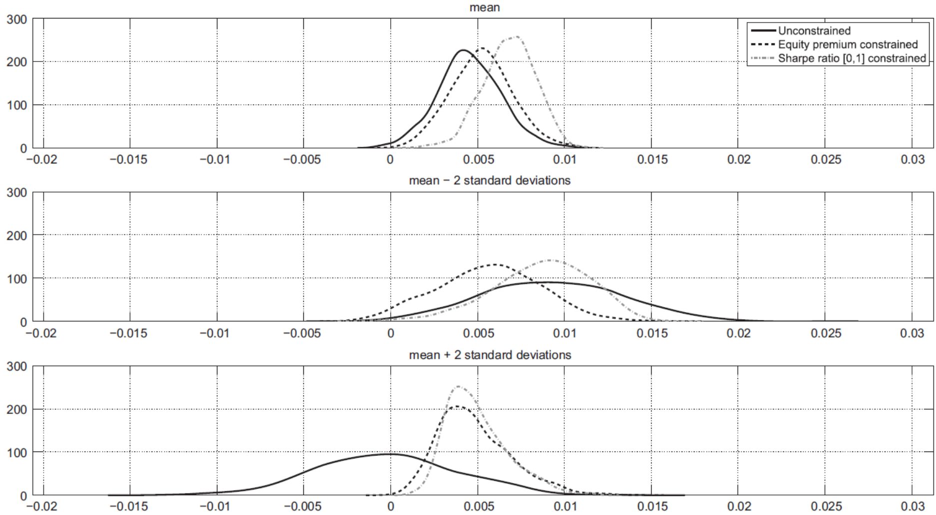
Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Full-sample posterior of the Equity premium: log dividend-price ratio



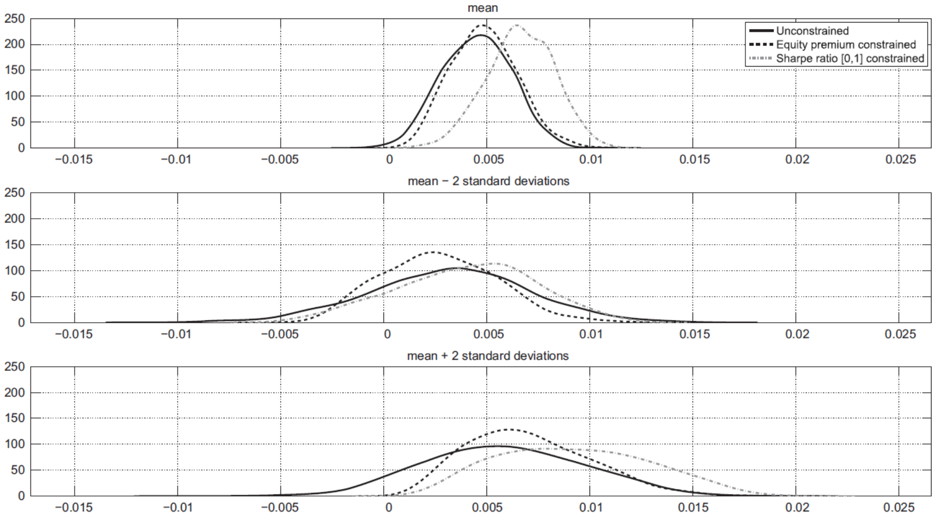
Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Full-sample posterior of the Equity premium: T-bill rate



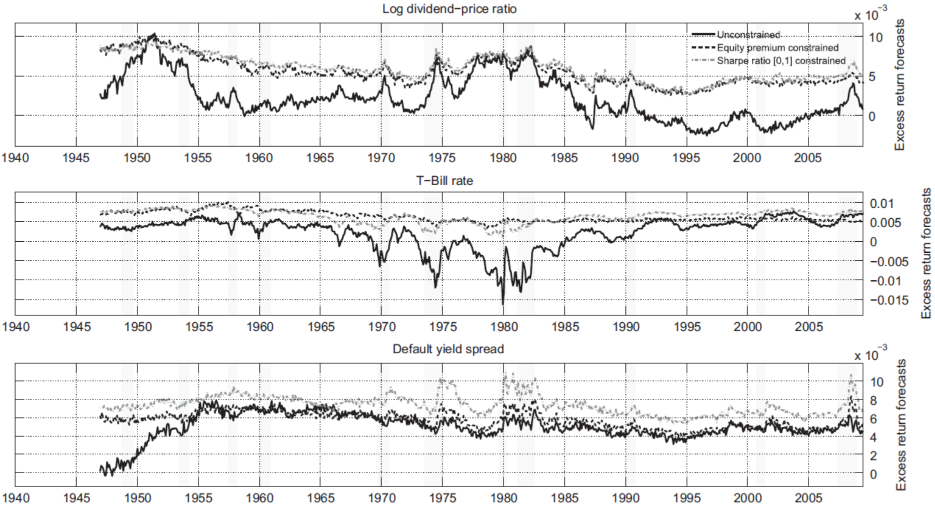
Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Full-sample posterior of the Equity premium: default yield spread



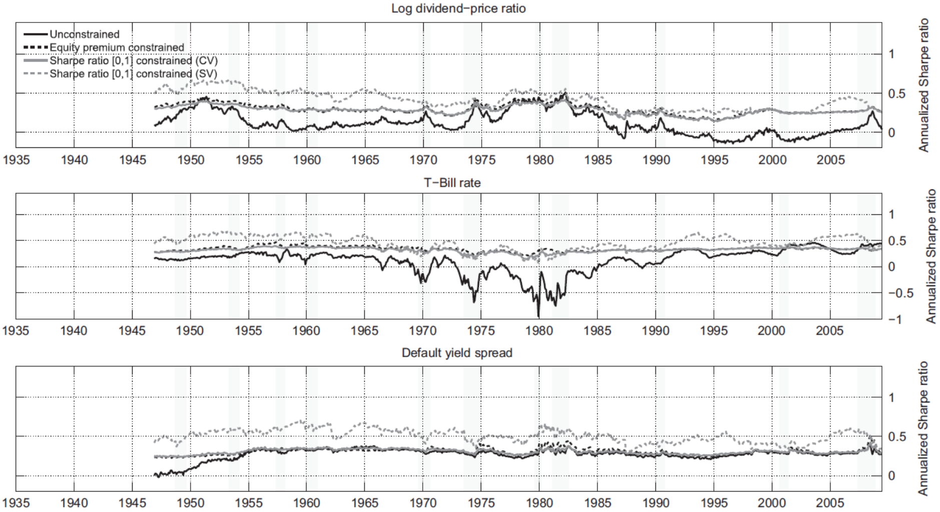
Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Out-of-sample equity premium forecast



Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Conditional Sharpe ratio



Pettenuzo, Timmermann, and Valkanov (2014, JFE)

Out-of-sample R^2

Monthly

	Panel A: full sample (1947–2010)			
Variable	No constraint	CT truncation	EP constraint	SR [0,1] constraint
Log dividend–price ratio	0.10%*	**0.25%****	**0.64%*****	**0.49%****

Quarterly

	Panel A: full sample (1947–2010)			
Variable	No constraint	CT truncation	EP constraint	SR [0,1] constraint
Log dividend–price ratio	−0.16%**	**1.20%****	**2.11%*****	**1.68%*****

Annual

	Panel A: full sample (1947–2010)			
Variable	No constraint	CT truncation	EP constraint	SR [0,1] constraint
Log dividend–price ratio	1.98%*	**3.14%***	**5.92%*****	**5.35%*****

Takeaway

- New method to impose constraint that rule out negative equity premia and bounds the Sharpe ratio
- Constraints affect the estimation procedure
- More efficient use of information available
- Smoother predictions: reduced effects of outliers

- Constraints improve forecasting accuracy