Quantitative Asset Management (MFE)

Bernard Herskovic

UCLA Anderson SCHOOL of MANAGEMENT

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1. Arbitrage Pricing Theory and Factor-Mimicking Portfolios
2. Betting Against Beta
3. Quality Minus Junk and Buffet's alpha
4. Currency

Risk comes in many flavors

- Before we can do performance analysis, we need a good model of risk and risk compensation in financial markets
- We used to think that priced risk comes in only a single flavor: β
- But we know now that risk comes in many flavors
  - Complicates portfolio advice
  - Makes performance analysis more challenging

Arbitrage Pricing Theory

- **Result: There exist risk prices for each factor such that the expected return on any security can be stated as:**

$$\mathbb{E}[R^e_{i,t}] = \lambda_0 + b_{i,1}\lambda_1 + b_{i,2}\lambda_2 + \ldots + b_{i,L}\lambda_L, \quad \text{for } i = 1, \ldots, N$$

- Very general
- No need to measure the return on the market
- The theory does not tell you which factors to use
- License to go fishing for priced risk factors...

Arbitrage Pricing Theory

- Suppose that the returns on stock i are generated by the following two-factor model:

$$R^e_{i,t} = a_i + b_{i,1}F_{1,t} + b_{i,2}F_{2,t} + e_{i,t}$$

- The two factors are I_1 andI_2 (e.g. industrial output growth and inflation)
- Each stock has different loadings $(b_{i,1}, b_{i,2})$ on the factors

$$\mathbb{E}[R^e_{i,t}] = \lambda_0 + b_{i,1}\lambda_1 + b_{i,2}\lambda_2$$

The risk prices are the expected excess returns on factor-mimicking portfolios: the factor-mimicking portfolio for inflation has exposure of one to inflation and zero to everything else

Risk Prices

- How do we recover these risk prices?

1. When the factors are traded returns, then the risk price is just the average of the factors
   - HML, SMB, ...
2. When the factors are not traded returns, then the risk price needs to be estimated in a two-pass regression.
   - GDP growth, inflation, industrial production growth
   - GMM estimation to get the correct standard errors

Testable version of APT: Tradeable factors

- Consider the following time series model of returns:

$$R_{i,t} - R_{f,t} = \alpha_i + b_{i,m}(R_{m,t} - R_{f,t}) + b_{i,bond}(R_{bond,t} - R_{f,t}) + \varepsilon_{i,t}$$

- Note that

$$\underbrace{\mathbb{E}[R_{i,t} - R_{f,t}]}_{\textbf{Actual Risk Premium}} = \underbrace{\alpha_i}_{\textbf{Pricing Error}} + \underbrace{b_{i,m}\mathbb{E}[R_{m,t} - R_{f,t}] + b_{i,bond}\mathbb{E}[R_{bond,t} - R_{f,t}]}_{\textbf{Predicted Risk Premium}}$$

To test this model, we can run a time series regression of returns on the intercept and the excess return on the market and the bond portfolio, and test whether the estimated intercept is statistically different from zero [each observation is a period]

Testable version of APT: Non-Tradeable factors

- Consider the following time series model of returns:

$$R_{i,t} - R_{f,t} = a_i + b_{i,m}(R_{m,t} - R_{f,t}) + b_{i,gdp}\Delta gdp_t + \varepsilon_{i,t}$$

- Note that

$$\underbrace{\mathbb{E}[R_{i,t} - R_{f,t}]}_{\textbf{Actual Risk Premium}} = \underbrace{a_i}_{\textbf{Not Pricing Error}} + \underbrace{b_{i,m}\mathbb{E}[R_{m,t} - R_{f,t}] + b_{i,gdp}\mathbb{E}[\Delta gdp_t]}_{\textbf{is not the Predicted Risk Premium}}$$

To test this model, we cannot run a time series regression of returns on the intercept and the excess return on the market and the bond portfolio, and test whether the estimated intercept is statistically different from zero

Testable version of APT: Non-Tradeable factors

- Consider the following time series model of returns:

$$R_{i,t} - R_{f,t} = a_i + b_{i,m}(R_{m,t} - R_{f,t}) + b_{i,gdp}\Delta gdp_t + \varepsilon_{i,t}$$

- Note that

$$\underbrace{\mathbb{E}[R_{i,t} - R_{f,t}]}_{\textbf{Actual Risk Premium}} = \underbrace{\alpha_i}_{\textbf{Pricing Error}} + \underbrace{b_{i,m}\lambda_m + b_{i,gdp}\lambda_{gdp}}_{\textbf{the Predicted Risk Premium}}$$

To test this model, we run a cross-sectional regression of average returns on the intercept and loadings (estimated from the time series regression) [each observation is a security]

Two-stage procedure:

Step 1: For each individual security: times-series regression

Step 2: Regress average returns on betas from the first stage (cross-sectional regression)

- We still need to correct the standard errors (Shanken correction or GMM)

How to apply this to quantitative asset management?

- The second-stage estimated prices are portfolios!
- If we are pricing N portfolios with K factors
- T is the number of periods
- Compute first-stage betas (time-series regression):

  $\beta_{i,k}$ for $i = 1, \ldots, N$ and $k = 1, \ldots, K$
- Second-stage coefficients (for each period t):

$$\lambda = \left[B'B\right]^{-1} B'R$$

  B is a $N \times K + 1$ matrix of estimated β's & a vector of ones
  R is a $N \times T$ matrix of stock returns
- To get the actual prices of risk estimates:

$$\lambda = \left[B'B\right]^{-1} B'\overline{R}$$

  $\overline{R}$ is $N \times 1$ column vector of time-series average returns

How to apply this to quantitative asset management?

- Prices of risk:

$$\lambda = \underbrace{\left[B'B\right]^{-1} B'}_{\text{Portfolio Weights}} \overline{R}$$

- λ's are portfolios
- even if factors are not tradeable

How to apply this to quantitative asset management?

Example with one factor

- Estimate beta (first-stage)

$$R_{i,t} - R_{f,t} = a_i + b_i F_t + \varepsilon_{i,t}$$

$$\therefore \hat{b}_i = \frac{Cov_t(R_{i,t} - R_{f,t}, F_t)}{Var_t(F_t)}$$

How to apply this to quantitative asset management?

Example with one factor

- Estimate prices of risk (second-stage)

$$
\begin{aligned}
\lambda_F &= \frac{Cov_i(\overline{R}_i^e, b_i)}{Var_i(b_i)} \\
&= \sum_{i=1}^{N} \frac{b_i - \overline{b}}{\sum_{s=1}^{N}\left(b_s - \overline{b}\right)^2} \overline{R}_i^e \\
&= \frac{1}{T} \sum_{i=1}^{N} \sum_{t=1}^{T} \underbrace{\frac{b_i - \overline{b}}{\sum_{s=1}^{N}\left(b_s - \overline{b}\right)^2}}_{\equiv w_{i,t}^f} (R_{i,t} - R_{f,t}) \\
&= \frac{1}{T} \sum_{t=1}^{T} \sum_{i=1}^{N} w_{i,t}^f (R_{i,t} - R_{f,t})
\end{aligned}
$$

- This is a long-short portfolio: $\sum_{i=1}^{N} w_{i,t}^f = 0$

How to apply this to quantitative asset management?

Example with one factor

- New factor

$$\tilde{F}_t = \sum_{i=1}^{N} w_{i,t}^{f} \left(R_{i,t} - R_{f,t}\right)$$

- Expected return (estimated):

$$\frac{1}{T}\sum_{t=1}^{T} \tilde{F}_t = \lambda_R$$

- $\tilde{F}_t$ delivers the premium of f_t and $\tilde{F}_t$ is tredeable!

Which Factors?

- One (ad hoc but effective) way to proceed is to use traded factors that we believe to be the main drivers of returns:
  1. Size factor
  2. Value or book-to-market factor
  3. Momentum factor
- This essentially means we are taking a shortcut: we're not trying to actually capture the sources of macroeconomic risk that are priced directly, but we're using traded factors that proxy for these macro-economic risks.

Fama and French Three-Factor Model

- Fama and French Three-factor Model for stock returns:

$$(R_{i,t} - R_{f,t}) = \alpha_i + b_{i,m}(R_{m,t} - R_{f,t}) + b_{i,smb}R_{smb,t} + b_{i,hml}R_{hml,t} + e_{i,t}$$

- Implication for APT:

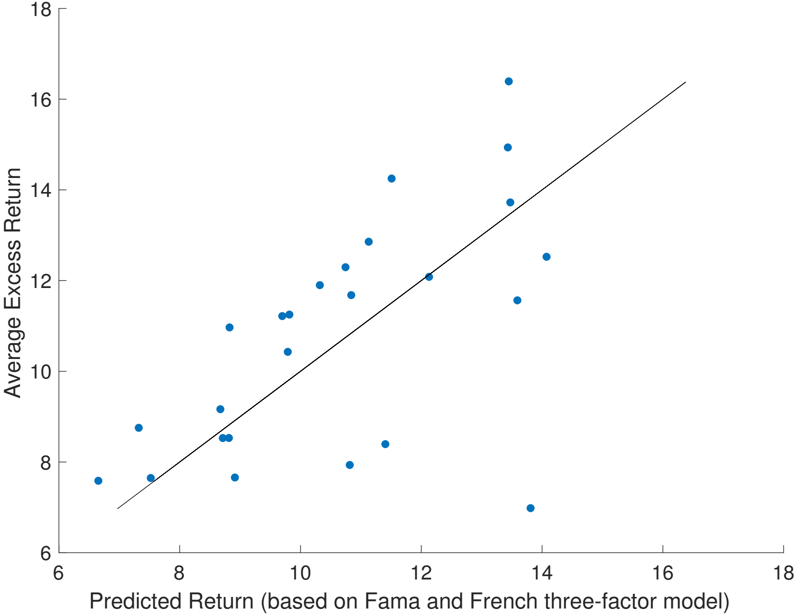
$$\mathbb{E}[R^e_{i,t}] = b_{i,m}\lambda_m + b_{i,smb}\lambda_{smb} + b_{i,hml}\lambda_{hml}, \quad i = 1, \ldots, N$$

- Let's test this asset pricing model on 25 portfolios (intersection of 5 portfolios sorted by size and 5 portfolios sorted by B/M)

Fama-French

- Three-factor model explains 95% of the variation in average returns on these 25 portfolios sorted by size and book-to-market
- We have an asset-pricing model that works
- What does it mean? The Fama-French interpretation:
  - Investors are rewarded for taking on covariance with HML or SMB
  - Investors are not rewarded for investing in small stocks or value stocks
- HML and SMB capture some other sources of macro-economic risk that affect the average investor

Second Stage



Other Test Assets

- HML and SMB cannot account for returns on portfolios of stocks sorted by momentum
- Momentum effect is really large!
- Momentum stocks do move together:
  - High momentum stocks move together with other high momentum stocks
  - Low momentum stocks move together with other low momentum stocks
- since momentum stocks co-move, adding a momentum factor eliminates the α on momentum portfolios
- Ad hoc solution: construct a momentum factor, CMA, RMW, BAB, QMJ, ...

Betting Against Beta

Frazzini and Pedersen (JFE, 2014)

The Failure of the CAPM

- Big assumption underlying the CAPM: all investors choose to invest in the maximum Sharpe ratio portfolio of risky assets and then lever up (down) to achieve the desired expected return
- However, a large fraction of investors does not have access to free leverage:
    - Individuals
    - Pension Funds
    - Mutual Funds

Constraints: No Leverage

- Some agents do not have access to leverage at all; these agents face the following constraint (with $m = 1$):

$$m \times \text{total value of securities} \leq \text{total wealth}$$

- This simply means that you cannot invest more than \$100 dollars when your wealth is \$100
- Some agents do not have access to leverage and need to hold cash; these agents face the following constraint (with $m > 1$):

$$m \times \text{total value of securities} \leq \text{total wealth}$$

- m=1.25 simply means that you cannot invest more than \$80 dollars when your wealth is \$100


m>1: needs to hold cash
E(r)
F
Capital Market Line
r_f
Market Price of Risk: Maximum Sharpe Ratio
$\sigma(r)$

Pricing Impact

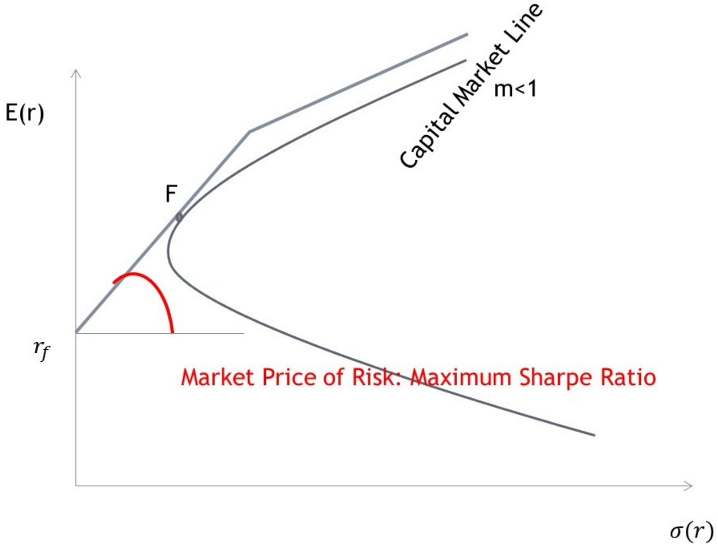
- These leverage-constrained investors will switch to investing in high-beta assets
  - High-beta assets are substitutes for leverage
  - They overweight high-beta assets and underweight low-beta assets
  - This extra demand for high beta assets pushes down their average returns
  - Example: instead of buying a 60/40 equity/bond portfolio and levering up, these leverage-constrained investors will buy a 90/10 portfolio

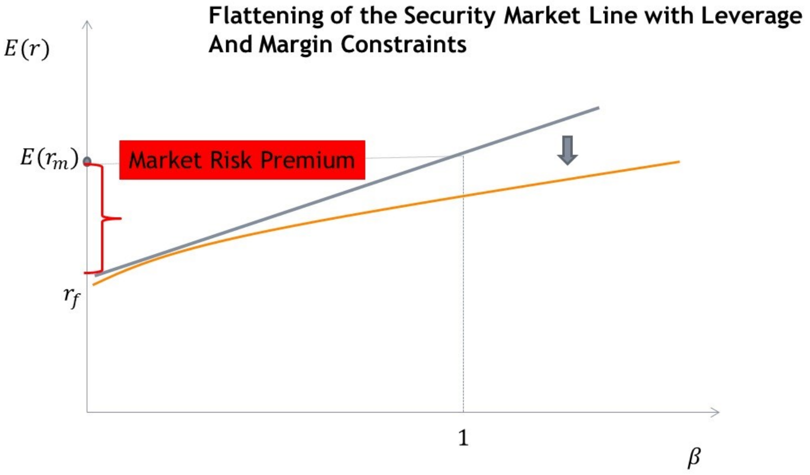
Constraints: Leverage

- Some agents do have access to leverage; these agents face the following constraint (with $m < 1$):

$$m \times \text{total value of securities} \leq \text{total wealth}$$

- This simply means that you cannot invest more than \$200 dollars when your wealth is \$100; the margin constraint is 50%


Capital Market Line
m<1
E(r)
F
r_f
Market Price of Risk: Maximum Sharpe Ratio
$\sigma(r)$


Flattening of the Security Market Line with Leverage And Margin Constraints
E(r)
E(r_m)
Market Risk Premium
r_f
1
β

Model

- OLG economy
- Agent i born at t lives for 2 periods
- Initial wealth: W_t^i
- Securities: $s = 1, \ldots, S$
- Dividend: δ_t^s
- Shares outstanding (supply): x^{*s}
- Optimization problem (mean-variance):

$$\max_x x' \left(\mathbb{E}_t \left[P_{t+1} + \delta_{t+1} \right] - (1 + r^f) P_t \right) - \frac{\gamma^i}{2} x' \Omega x$$

s.t.

$$m_t^i x' P_t \leq W_t^i$$

Model

- Market Clearing (sum across agents)

$$\sum_i x^i = x^*$$

- FOC

$$0 = \mathbb{E}_t \left[P_{t+1} + \delta_{t+1}\right] - (1 + r^f) P_t \gamma^i \Omega x - \psi_t^i P_t$$

which implies

$$x^i = \frac{1}{\gamma^i} \Omega^{-1} \left[\mathbb{E}_t \left[P_{t+1} + \delta_{t+1}\right] - (1 + r^f + \psi_t^i) P_t\right]$$

where ψ_t^i is the Lagrange multiplier

Model

- Market clearing implies

$$x^* = \frac{1}{\gamma}\Omega^{-1}\left[\mathbb{E}_t\left[P_{t+1} + \delta_{t+1}\right] - (1 + r^f + \psi_t)P_t\right]$$

where $\frac{1}{\gamma} = \sum_i \frac{1}{\gamma^i}$ and $\psi_t = \sum_i \frac{\gamma}{\gamma^i}\psi_t^i$

- Prices

$$P_t = \frac{\mathbb{E}_t\left[P_{t+1} + \delta_{t+1}\right] - \gamma\Omega x^*}{1 + r^f + \psi_t}$$

- Returns

$$r_{t+1}^s = \frac{P_{t+1}^s + \delta_{t+1}^s}{P_t^s} - 1$$

- Beta

$$\beta_t^s = \frac{Cov_t(r_{t+1}^s, r_{t+1}^M)}{Var_t(r_{t+1}^M)}$$

Model: Proposition 1

High beta is low alpha

(i) The equilibrium required return for any security s is

$$\mathbb{E}_t\left[r^s_{t+1}\right] = r^f + \psi_t + \beta^s_t \lambda_t$$

where the risk premium is $\lambda_t = \mathbb{E}_t\left[r^M_{t+1}\right] - r^f - \psi_t$

(ii) A security's alpha with respect to the market is

$$\alpha^s_t = \psi_t(1 - \beta^s_t)$$

The alpha decreases in the beta β^s_t

(iii) For an efficient portfolio, the Sharpe ratio is highest for an efficient portfolio with a beta less than one and decreases in β^s_t for higher betas and increases for lower betas

Model: BAB Factor

Betting against factor

- Low-beta portfolio

$$r_{t+1}^{L} = w_L' r_{t+1}$$

where w_L are portfolio weights

- High-beta portfolio

$$r_{t+1}^{H} = w_H' r_{t+1}$$

where w_H are portfolio weights

- Portfolio betas: $\beta_t^L < \beta_t^H$
- Betting against factor

$$r_{t+1}^{BAB} = \frac{1}{\beta_t^L}\left(r_{t+1}^{L} - r^f\right) - \frac{1}{\beta_t^H}\left(r_{t+1}^{H} - r^f\right)$$

Model: Proposition 2

Positive expected return of BAB

- The expected excess return of the self-financing BAB factor is positive

$$\mathbb{E}_t\left[r_{t+1}^{BAB}\right] = \frac{\beta_t^H - \beta_t^L}{\beta_t^L \beta_t^H}\psi_t \geq 0$$

and increasing in the ex-ante beta spread $\frac{\beta_t^H - \beta_t^L}{\beta_t^L \beta_t^H}$ and funding tightness ψ_t

Model: Proposition 3

Funding shocks and BAB returns

- A tighted portfolio constraint, that is, an increase in m_t^k for some of k, leads to a contemporaneous loss for the BAB factor

$$\frac{\partial r_t^{BAB}}{\partial m_t^k} \leq 0$$

and an increase in its future required return

$$\frac{\partial \mathbb{E}_t \left[r_{t+1}^{BAB} \right]}{\partial m_t^k} \geq 0$$

Model: Proposition 5

Constrained investors hold high betas

- Unconstrained agents hold a portfolio of risky securities that has a beta less than one; constrained agents hold portfolios of risky securities with higher betas. If securities s and k are identical except that s has a larger market exposure than k, $b^s > b^k$, then any constrained agent j with greater than average Lagrange multiplier, $\psi_t^j > \psi_t$, holds more shares of s than k. The reverse is true for any agent with $\psi_t^j < \psi_t$.

Betting against Beta

- Building on these ideas, Frazzini and Pedersen build 'betting against beta' portfolios
- The BAB factor has a zero beta. It is a zero-cost portfolio that goes long in low-beta assets, short in high-beta assets and the risk-free.
- Construction of the BAB factor for US stocks: long 1.4$ of low-beta stocks, short $0.70 high-beta stocks and offsetting position in the risk-free to make it a zero-cost portfolio.
- The BAB factor has a Sharpe ratio of 0.75 with a zero beta

Betting against Beta Portfolios

Estimating ex ante betas

$$\hat{\beta}_i^{ts} = \hat{\rho}\frac{\hat{\sigma}_i}{\hat{\sigma}_m}$$

- Correlation: $\hat{\rho}$
  - five-year rolling window
  - three-day log return
  - at least six months of data (120 trading days) for daily data
  - at least 12 months of data for monthly data
- Volatility: $\hat{\sigma}_i$ and $\hat{\sigma}_m$
  - one-year rolling window
  - one-day log return
  - at least three year of data (750 trading days) for daily data
  - at least 36 months of data for monthly data

Betting against Beta Portfolios

Estimating ex ante betas

- Apply a shrinkage factor to the estimated betas to eliminate the effect of outliers:

$$\hat{\beta} = w_i \times \hat{\beta}_i^{ts} + (1 - w_i) \times \hat{\beta}^{xs}$$

  but they set $w_i = 0.6$ and $\hat{\beta}^{xs} = 1$
- Rank all stocks according to their estimated betas
  - Does the shrinkage affect the sorting?

Betting against Beta Portfolios

Portfolio weights

- Divide into a high and low beta portfolio
  - Use median as breakpoint
  - Monthly rebalancing
- Portfolio weights: w_L and w_H
  - Ranks: $z = rank(\beta_{it})$ (vector)
  - Average rank: $\overline{z} = 1_n' z/n$ (scalar)

$$w_H = k(z - \overline{z})^+$$
$$w_L = k(z - \overline{z})^-$$

    where $k = 2/1_n'|z - \overline{z}|$
  - Weights sum to one: $1_n' w_L = 1_n' w_H = 1$

Betting against Beta Portfolios

BAB portfolios

- Construct the BAB factor

$$r_{t+1} = \frac{1}{\beta_L}\left(r_{t+1}^{L} - r^{f}\right) - \frac{1}{\beta_H}\left(r_{t+1}^{H} - r^{f}\right)$$

where

$$\begin{aligned} r_{t+1}^{L} &= r_{t+1}' w_L \\ r_{t+1}^{H} &= r_{t+1}' w_H \\ \beta_L &= \beta_t' w_L \\ \beta_H &= \beta_t' w_H \end{aligned}$$

BAB for US Stocks

Table 3: testing Propositions 1 and 2

Equally-weighted beta-sorted portfolios (deciles, NYSE breakpoint) and BAB

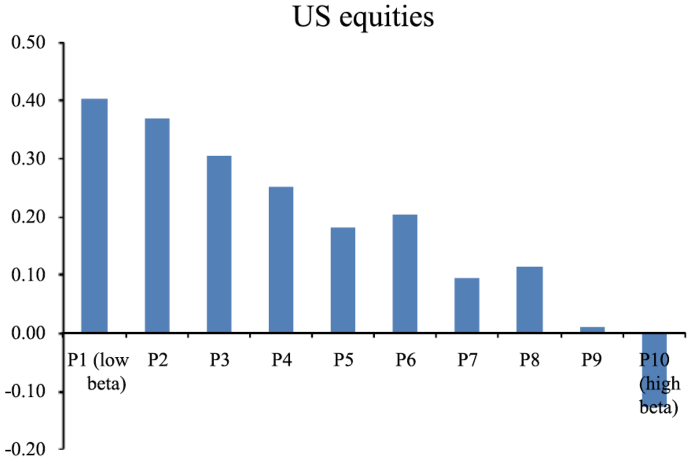
Portfolio	P1 (low beta)	P2	P3	P4	P5	P6	P7	P8	P9	P10 (high beta)	BAB
Excess return	**0.91**	**0.98**	**1.00**	**1.03**	**1.05**	**1.10**	**1.05**	**1.08**	**1.06**	**0.97**	**0.70**
	(6.37)	(5.73)	(5.16)	(4.88)	(4.49)	(4.37)	(3.84)	(3.74)	(3.27)	(2.55)	(7.12)
CAPM alpha	**0.52**	**0.48**	**0.42**	**0.39**	**0.34**	**0.34**	0.22	0.21	0.10	−0.10	**0.73**
	(6.30)	(5.99)	(4.91)	(4.43)	(3.51)	(3.20)	(1.94)	(1.72)	(0.67)	(−0.48)	(7.44)
Three-factor alpha	**0.40**	**0.35**	**0.26**	**0.21**	**0.13**	0.11	−0.03	−0.06	**−0.22**	**−0.49**	**0.73**
	(6.25)	(5.95)	(4.76)	(4.13)	(2.49)	(1.94)	(−0.59)	(−1.02)	(−2.81)	(−3.68)	(7.39)
Four-factor alpha	**0.40**	**0.37**	**0.30**	**0.25**	**0.18**	**0.20**	0.09	0.11	0.01	−0.13	**0.55**
	(6.05)	(6.13)	(5.36)	(4.92)	(3.27)	(3.63)	(1.63)	(1.94)	(0.12)	(−1.01)	(5.59)
Five-factor alpha	**0.37**	**0.37**	**0.33**	**0.30**	**0.17**	**0.20**	0.11	0.14	0.02	0.00	**0.55**
	(4.54)	(4.66)	(4.50)	(4.40)	(2.44)	(2.71)	(1.40)	(1.65)	(0.21)	(−0.01)	(4.09)
Beta (ex ante)	0.64	0.79	0.88	0.97	1.05	1.12	1.21	1.31	1.44	1.70	0.00
Beta (realized)	0.67	0.87	1.00	1.10	1.22	1.32	1.42	1.51	1.66	1.85	−0.06
Volatility	15.70	18.70	21.11	23.10	25.56	27.58	29.81	31.58	35.52	41.68	10.75
Sharpe ratio	0.70	0.63	0.57	0.54	0.49	0.48	0.42	0.41	0.36	0.28	0.78

Factors: 3FF, Momentum, and PS liquidity

Extra problem set for fun: Replicate this table? tricky because of daily data

BAB for US Stocks

Alphas (figure 1)



Betting against Beta

Coincidence or data mining? maybe not

- Consistent across countries, time, within deciles sorted by size, within deciles sorted by idiosyncratic volatility, robust to several specifications
- Hold across different asset classes: US treasuries and credit market (corporate bonds), commodities, currency
- Verify economic mechanism? Supporting evidence:

Prop 3 High TED spreads are associated with lower contemporaneous BAB returns, but lagged TED spreads negatively predicts BAB returns (Table 9)

Prop 4 Beta dispersion is lower when funding liquidity risk is high (Table 10)

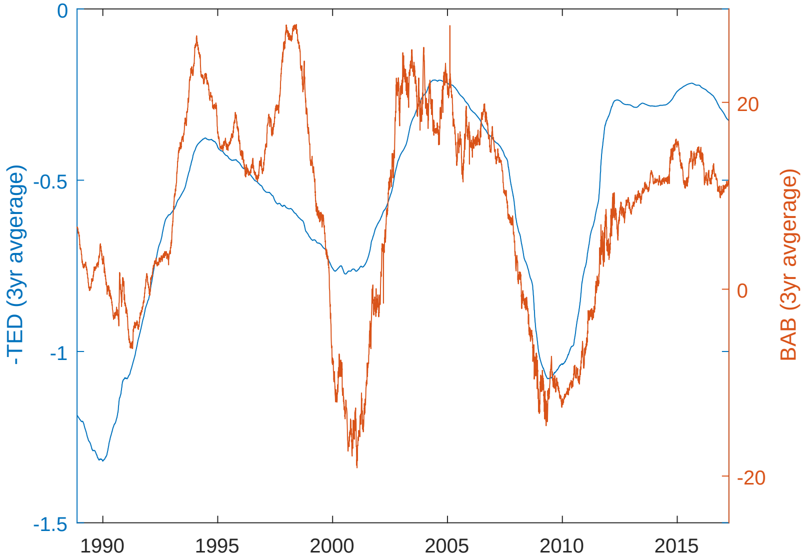
Prop 5 Leveraged-constrained investors (mutual funds, individual investors) have beta above one, while less constrained (PE, BRK) have betas below one (Table 11)

Risk Parity

- This is the part of the rationale for the risk parity portfolio allocation strategy: overweight low risk assets, underweight high risk assets, and then lever up/down so the overall risk contribution from each asset class is equalized
- This works to the extent that low risk asset classes have lower betas

Unwinding of BAB trade

- But there is risk involved...
- When levered investors face binding margin constraints, they have to reduce leverage and sell (low-beta) assets
- Unwinding of the BAB trade results in large losses during financial crises



This figures shows annualized 3-year average return of the US stocks BAB factor (right scale) and 3-year negative average rolling TED spread (right scale). Sample from 1988.11 to 2017.03

Takeaway

- Security Market Line is 'too flat'
- High-beta stocks have lower alpha and low-beta stocks have higher alpha
- BAB: long low-beta stocks and short high-beta stocks
- BAB has zero beta on the market portfolio
- Economic mechanism: leverage constraint

Quality minus Junk and Buffett's Alpha

The Oracle's performance

- Berkshire Hathaway has a SR of 0.76 over the period 1976-2011 [highest SR for all stocks traded $>$ 30 years]
- Does this high SR reflect riskiness of BH's holdings or the magic hot hands of Buffett?
- Buffett picks stocks that are
  - Cheap
  - Safe
  - High quality
- BH is also levered 1.6 to 1 on average to boost returns some more

Buffett's Performance compared to mutual funds

SR of Equity Mutual Funds		Rank	Percentile	
All funds in CRSP	Number of funds/stocks	88	97.5%	
All funds in CRSP alive in 1976 and 2011		1	100%	

Source: D. Kabiller, A. Frazzini and L.H. Pedersen, Buffett's Alpha, NBER Working Paper No. 19681

New Factors

- New factors are constantly being discovered in stock markets:
  - Betting against Beta [BAB] Factor (Frazzini and Pedersen, 2012)
  - Quality minus Junk [QMJ] Factor (Asness, Frazzini and Pedersen, 2014).

New Factors: Quality Minus Junk

- Quality is defined as:

  Develop a z-score for (Profitability+Growth+Safety)

  1. Safety: more safety, lower required rate of return
  2. Profitability: profit per unit of book value
  3. Growth: higher price for stocks which grow faster
  4. Payout ratio: fraction of profits paid to shareholders

From Gordon's growth model:

$$\frac{P}{B} = \frac{D/B}{r-g} = \frac{Profit/B \times D/Profit}{r-g} = \frac{\text{profitability} \times \text{payout ratio}}{\text{required return} - \text{growth}}$$

Quality: Profitability score

Develop a z-score for Profitability

$$Profitability = z\left(z_{gpoa} + z_{roe} + z_{roa} + z_{cfoa} + z_{gmar} + z_{acc}\right)$$

- Gross profits over assets (gpoa)
- Return on equity (roe)
- Return on Assets (roa)
- Cash flow over assets (cfoa)
- Gross margin (gmar)
- Fraction of earnings composed of cash, low accruals (acc)

Quality: Growth score

Develop a z-score for Growth

$$Growth = z\left(z_{\Delta gpoa} + z_{\Delta roe} + z_{\Delta roa} + z_{\Delta cfoa} + z_{\Delta gmar}\right)$$

- Gross profits over assets (gpoa)
- Return on equity (roe)
- Return on Assets (roa)
- Cash flow over assets (cfoa)
- Gross margin (gmar)

Quality: Safety score

Develop a z-score for Safety

$$Safety = z\left(z_{bab} + z_{lev} + z_o + z_z + z_{evol}\right)$$

- Minus market beta (bab)
- Minus total debt over total assets (lev)
- Ohlson's O-score (o)
- Altman's Z-socre (z)
- Stadard deviation of quarterly ROE (evol)

New Factors: Quality Minus Junk

- Quality is defined as:

  Develop a z-score for (Profitability+Growth+Safety)

  1. Safety (low r): more safety, lower required rate of return
  2. Profitability: profit per unit of book value
  3. Growth: higher price for stocks which grow faster
  4. Payout ratio: fraction of profits paid to shareholders

$$\frac{P}{B} = \frac{D/B}{r-g} = \frac{\text{profitability} \ \times \ \text{payout ratio}}{\text{required return} \ - \ \text{growth}}$$

- Quality is a stock-level characteristic

New Factors: Quality Minus Junk

- Higher quality stocks should command higher prices but Quality has very little effect on the level of prices ('the price of quality is positive but quite low')
  - The market seems to underprice quality
- As a result, quality has a huge effect on returns: high quality firms outperform low quality firms by a large margin

New Factors: Quality Minus Junk

	P1	P10	H-L
Excess Returns	0.15	0.61	0.47
CAPM alpha	-0.53	0.18	0.71
4-factor alpha	-0.56	0.41	0.97

Notes; US 1956-2012. Monthly Data and Returns. Source: Quality minus Junk, Table IV

New Factors: Quality Minus Junk

- The intersection of these creates six portfolios

30th percentile 70th percentile

Median ME

	Low quality	medium	High quality
Small	Small junk	Small neutral	Small quality
large	Large junk	Large neutral	Large quality

New Factors: Quality Minus Junk

- QMJ is the average return on a long position in the two quality portfolios and a short position in the two junk portfolios:

$$QMJ = \frac{1}{2}\,(\text{Small Quality } + \text{ Large Quality})$$

$$-\,\frac{1}{2}\,(\text{Small Junk } + \text{ Large Junk})$$

Buffett stock picker?

- Buffett is known as a stock picker, but you can explain a big share of what he does by focusing on stock screens (systematically implemented)
- Once we control for all these factors (including the new ones), Buffett's alpha is insignificant:
  - Market
  - HML (value)
  - SMB (size)
  - UMD (momentum)
  - BAB (betting against beta)
  - QMJ (quality)

Measuring The Oracle's Alpha

- Berkshire Hathaway has a SR of 0.76 over the period 1976-2011 [highest SR for stocks traded > 30 years]
  - BH is also levered 1.6 to 1 on average to boost returns some more
- Does this high SR reflect riskiness of BH's holdings or the magic hot hands of Buffett?
- We can run a time series regression of BH stock returns on the 6 factors
  - Those last two factors turn out to matter a lot.

Buffett's exposures and his alpha; the stock

Alpha	12.1%	9.2%	6.3%
T-stat	3.19	2.42	1.58
MKT	0.84	0.83	0.95
SMB	-0.32	-0.32	-0.15
HML	0.63	0.38	0.46
UMD	0.06	-0.03	-0.03
BAB		0.37	0.29
QMJ			0.43
R^2	0.25	0.27	0.28

Berkshire's Stock (1976-2011)
Source: D. Kabiller, A. Frazzini and L.H. Pedersen, Buffett's Alpha, NBER Working Paper No. 19681. Table 4.

Buffett's exposures and his alpha: holdings of public stock

Alpha	5.3%	3.5%	0.3%
T-stat	2.53	1.65	0.12
MKT	0.86	0.86	0.98
SMB	-.18	-0.18	-0.18
HML	0.39	0.24	0.31
UMD	-0.02	-0.08	-.10
BAB		0.22	0.15
QMJ			0.44
R^2	0.57	0.58	0.60

Berkshire's 13F portfolio 1980-2011

Source: D. Kabiller, A. Frazzini and L.H. Pedersen, Buffett's Alpha, NBER Working Paper No. 19681. Table 4.

Summary

- Buffett posts impressive performance
- Much of this performance can be attributed to systematic risk exposure:
  1. QMJ: long in quality, short in junk
  2. BAB: long in low-vol, short in high-vol.
- But Buffett's investments picks predate this work documenting BAB/QMJ effects
- Hence, his investment performance is truly impressive (even though it may not deliver pure alpha)
  - As we discover more risk factors, alpha is relabeled as exposure to quality, low-risk, etc.
- Good example of how to use BAB, QMJ, and other factors.
- Use of 13f data for holdings of public stocks (quarterly)

QMJ Takeaway

- Define a quality security as one that has characteristics that should command a higher price
- Quality stocks are profitable, growing, and safe.
- Quality-minus-junk (QMJ) factor that goes long high-quality stocks and shorts low-quality stocks earns significant risk-adjusted returns
- Our results are consistent with quality stocks being underpriced and junk stocks overpriced or, alternatively, with quality stocks being riskier than junk stocks
- Strong and consistent abnormal returns to quality
- An important puzzle for asset pricing? Returns to quality could be an anomaly, data mining, or another risk factor risk factor?

Common risk factors in currency markets

Lustig, Roussanov, and Verdelhan (RFS, 2011)

Common risk factors in currency markets

- Risk-based view of currency premia
- Large co-movement among exchange rates of different currencies
- Slope factor in exchange rate changes
- Exposure: covariation with this slope factor accounts for most of the spread in average returns between baskets of high and low interest rate currencies
- High interest rate currencies load more on this slope factor than low interest rate currencies
- Global risk factor is closely related to changes in volatility of equity markets around the world.
- Rational explanation for the failure of the Uncovered Interest rate parity

Currency Portfolios

- Focus on forward and spot currency markets
- Log currency excess returns:

$$
\begin{aligned}
rx_{t+1} &= f_t - s_{t+1} \\
&= f_t - s_t - (s_{t+1} - s_t) \\
&= f_t - s_t - \Delta s_{t+1} \\
&\approx i_t^* - i_t - \Delta s_{t+1}
\end{aligned}
$$

- Use bid-ask spread to compute realized returns

Currency Portfolios

Data:

- Daily spot and forward exchange rates in U.S. dollars.
- November 1983 to December 2009
- Data from Barclays and Reuters (Datastream)
- 35 different currencies: Australia, Austria, Belgium, Canada, Hong Kong, Czech Republic, Denmark, euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, and the United Kingdom.

Currency Portfolios

Data:

- Six portfolios/baskets of currencies
- Monthly rebalancing
- Portfolios sorted from low to high interest rate
- Compute return: rx_{t+1}^j for portfolio j by taking the average of the log currency excess returns in each portfolio j
- Number of currencies varies over time: 9-26
- Returns are from the perpective os US investor

Table 1: Currency portfolios—U.S. investor

Portfolio	1	2	3	4	5	6	1	2	3	4	5
	Panel I: All Countries						Panel II: Developed Countries				
	Spot change: Δs^j						Δs^j				
Mean	−0.64	−0.92	−0.95	−2.57	−0.60	2.82	−1.81	−1.87	−3.28	−1.57	−0.82
Std	8.15	7.37	7.63	7.50	8.49	9.72	10.17	9.95	9.80	9.54	10.26
	Forward Discount: $f^j - s^j$						$f^j - s^j$				
Mean	−2.97	−1.23	−0.09	1.00	2.67	9.01	−2.95	−0.94	0.11	1.18	3.92
Std	0.54	0.48	0.47	0.52	0.64	1.89	0.77	0.62	0.63	0.66	0.74
	Excess Return: rx^j (without b–a)						rx^j (without b–a)				
Mean	−2.33	−0.31	0.86	3.57	3.27	6.20	−1.14	0.93	3.39	2.74	4.74
Std	8.23	7.44	7.66	7.59	8.56	9.73	10.24	9.98	9.89	9.62	10.33
SR	−0.28	−0.04	0.11	0.47	0.38	0.64	−0.11	0.09	0.34	0.29	0.46
	Net Excess Return: rx^j_{net} (with b–a)						rx^j_{net} (with b–a)				
Mean	−1.17	−1.27	−0.39	2.26	1.74	3.38	−0.02	−0.11	2.02	1.49	3.07
Std	8.24	7.44	7.63	7.55	8.58	9.72	10.24	9.98	9.87	9.63	10.32
SR	−0.14	−0.17	−0.05	0.30	0.20	0.35	−0.00	−0.01	0.21	0.15	0.30
	High-minus-Low: $rx^j - rx^1$ (without b–a)						$rx^j - rx^1$ (without b–a)				
Mean		2.02	3.19	5.90	5.60	8.53		2.07	4.53	3.88	5.88
Std		5.37	5.30	6.16	6.70	9.02		7.18	7.11	8.02	9.64
SR		0.38	0.60	0.96	0.84	0.95		0.29	0.64	0.48	0.61
	High-minus-Low: $rx^j_{net} - rx^1_{net}$ (with b–a)						$rx^j_{net} - rx^1_{net}$ (with b–a)				
Mean		−0.10	0.78	3.42	2.91	4.54		−0.09	2.04	1.51	3.09
		[0.30]	[0.30]	[0.35]	[0.38]	[0.51]		[0.41]	[0.40]	[0.45]	[0.54]
Std		5.40	5.32	6.15	6.75	9.05		7.20	7.11	8.04	9.66
SR		−0.02	0.15	0.56	0.43	0.50		−0.01	0.29	0.19	0.32
	Panel I: All Countries						Panel II: Developed Countries				
	Real Interest Rate Differential: $r^j - r$						$r^j - r$				
Mean	−1.81	−0.13	0.45	1.04	1.80	3.78	−1.11	0.20	0.76	1.27	3.01
Std	0.56	0.56	0.49	0.57	0.65	0.77	0.78	0.60	0.62	0.62	0.71
	Frequency										
Trades/currency	0.20	0.34	0.41	0.44	0.42	0.14	0.14	0.28	0.36	0.35	0.10

Currency Portfolios

- UIP condition: the average rate of depreciation (spot change) = average forward discount
- Failure of UIP: currencies in the first portfolio trade at an average forward discount of 297 basis points, but they appreciate on average by only 64 basis points over this sample.
  - Long-short strategy's Sharpe ratio: 0.95
- Similar finding for log currency excess returns net of transaction costs.
  - Long-short strategy's Sharpe ratio: 0.50

Level versus Changes

- Are investors compensated for investing in high interest rate currencies or for investing in currencies with currently high interest rates?
- Split sample in two: sort based on the first part and verify returns in the second part of the sample.

Table 2: sorts on mean forward discounts (half sample)

Portfolio	1	2	3	4	5	6	1	2	3	4	5
	Panel I: All Countries						Panel II: Developed Countries				
	Sorts on Mean Forward Discounts (Half Sample)										
	Excess Return: rx^j (without b–a)						rx^j (without b–a)				
Mean	−2.28	−0.69	0.09	1.14	1.74	3.06	−2.94	−0.61	2.01	1.44	1.86
SR	−0.24	−0.18	0.01	0.15	0.18	0.26	−0.28	−0.06	0.24	0.15	0.21
	Net Excess Return: rx^j_{net} (with b–a)						rx^j_{net} (with b–a)				
Mean	−1.52	−1.21	−0.67	0.45	0.67	1.31	−1.94	−1.42	1.18	0.26	0.48
Std	9.45	3.78	7.32	7.75	9.95	11.88	10.41	10.32	8.37	9.49	9.02
SR	−0.16	−0.32	−0.09	0.06	0.07	0.11	−0.19	−0.14	0.14	0.03	0.05
	High-minus-Low: $rx^j_{net} - rx^1_{net}$ (with b–a)						$rx^j_{net} - rx^1_{net}$ (with b–a)				
Mean		0.32	0.86	1.97	2.19	2.83		0.51	3.11	2.20	2.42
SR		0.04	0.10	0.23	0.25	0.23		0.05	0.25	0.20	0.21
	Real Interest Rate Differences: $r^j - r$						$r^j - r$				
Mean	−0.96	0.52	−0.23	0.61	0.92	2.43	−1.16	−0.68	0.48	0.27	1.56
Std	0.44	0.60	0.49	0.43	0.55	0.49	0.73	0.42	0.44	0.47	0.45
	Sorts on Current Forward Discounts (Half Sample)										
	Excess Return: rx^j (without b–a)						rx^j (without b–a)				
Mean	−3.83	−1.36	0.22	1.99	2.22	6.33	−2.25	−0.53	0.91	1.94	3.90
SR	−0.50	−0.20	0.03	0.32	0.29	0.67	−0.24	−0.06	0.10	0.22	0.37
	Net Excess Return: rx^j_{net} (with b–a)						rx^j_{net} (with b–a)				
Mean	−2.81	−2.23	−0.70	1.02	0.81	3.46	−1.26	−1.48	−0.15	0.84	2.50
SR	−0.37	−0.33	−0.10	0.16	0.11	0.37	−0.13	−0.16	−0.02	0.10	0.24
	Panel I: All Countries						Panel II: Developed Countries				
	High-minus-Low: $rx^j_{net} - rx^1_{net}$ (with b–a)						$rx^j_{net} - rx^1_{net}$ (with b–a)				
Mean		0.58	2.11	3.83	3.63	6.28		−0.22	1.11	2.10	3.76
SR		0.11	0.43	0.66	0.54	0.70		−0.03	0.14	0.24	0.35
	Real Interest Rate Differences: $r^j - r$						$r^j - r$				
Mean	−1.43	−0.12	0.30	0.81	1.31	3.65	−1.40	−0.26	0.25	0.75	2.69
Std	0.49	0.49	0.33	0.47	0.55	0.67	0.72	0.43	0.42	0.49	0.56

Principal Components

- Take portfolios from Table 1
- Compute principal components

Table 3: Principal Components

Level and Slope Factors?

Panel I: All Countries

Portfolio	1	2	3	4	5	6
1	0.42	0.43	0.18	−0.15	0.74	0.20
2	0.38	0.24	0.15	−0.27	−0.61	0.58
3	0.38	0.29	0.42	0.12	−0.28	−0.71
4	0.38	0.04	−0.35	0.83	−0.03	0.18
5	0.43	−0.08	−0.72	−0.44	−0.03	−0.30
6	0.45	−0.81	0.35	−0.03	0.11	0.06
% Var.	71.95	11.82	5.55	4.00	3.51	3.16

Panel II: Developed Countries

Portfolio	1	2	3	4	5
1	0.44	0.66	−0.54	−0.25	0.12
2	0.45	0.25	0.75	0.01	0.41
3	0.46	0.02	0.19	0.04	−0.86
4	0.44	−0.27	−0.29	0.78	0.20
5	0.45	−0.66	−0.14	−0.57	0.17
% Var.	78.23	10.11	4.97	3.49	3.20

Factors

Level and Slope Factors?

- Average accross all portfolios (level)

  99% correlation with PC1
- Long short portfolio, HML_{FX} (slope)

  94% correlation with PC2

- Use two factor to estimate prices of risk

$$E[Rx^j] = \lambda' \beta^j$$

Estimate prices of risk: GMM or two-stage Fama and Macbeth

Table 4: Asset pricing—U.S. investor

Panel I: Risk Prices

	All Countries							Developed Countries						
	$\lambda_{HML_{FX}}$	λ_{RX}	$b_{HML_{FX}}$	b_{RX}	R^2	RMSE	χ^2	$\lambda_{HML_{FX}}$	λ_{RX}	$b_{HML_{FX}}$	b_{RX}	R^2	RMSE	χ^2
GMM_1	5.50	1.34	0.56	0.20	70.11	0.96		3.29	1.90	0.29	0.20	64.78	0.64	
	[2.25]	[1.85]	[0.23]	[0.32]			14.39%	[2.59]	[2.20]	[0.23]	[0.23]			45.96%
GMM_2	5.51	0.40	0.57	0.04	41.25	1.34		3.91	3.07	0.35	0.32	−55.65	1.34	
	[2.14]	[1.77]	[0.22]	[0.31]			16.10%	[2.52]	[2.05]	[0.22]	[0.22]			52.22%
FMB	5.50	1.34	0.56	0.20	70.11	0.96		3.29	1.90	0.29	0.20	64.78	0.64	
	[1.79]	[1.35]	[0.19]	[0.24]			9.19%	[1.91]	[1.73]	[0.17]	[0.18]			43.64%
	(1.79)	(1.35)	(0.19)	(0.24)			10.20%	(1.91)	(1.73)	(0.17)	(0.18)			44.25%
Mean	**5.08**	**1.33**					**3.14**	**1.90**						

Panel II: Factor Betas

Portfolio	All Countries						Developed Countries					
	α_0^j	$\beta_{HML_{FX}}^j$	β_{RX}^j	R^2	$\chi^2(\alpha)$	p–value	α_0^j	$\beta_{HML_{FX}}^j$	β_{RX}^j	R^2	$\chi^2(\alpha)$	p–value
1	−0.10	−0.39	1.05	91.64			0.36	−0.51	0.99	94.31		
	[0.50]	[0.02]	[0.03]				[0.53]	[0.03]	[0.02]			
2	−1.55	−0.11	0.94	77.74			−1.17	−0.09	1.01	80.69		
	[0.73]	[0.03]	[0.04]				[0.85]	[0.04]	[0.04]			
3	−0.54	−0.14	0.96	76.72			0.62	−0.00	1.04	86.50		
	[0.74]	[0.03]	[0.04]				[0.79]	[0.03]	[0.03]			
4	1.51	−0.01	0.95	75.36			−0.17	0.12	0.97	82.84		
	[0.77]	[0.03]	[0.05]				[0.85]	[0.03]	[0.04]			
5	0.78	0.04	1.06	76.41			0.36	0.49	0.99	94.32		
	[0.82]	[0.03]	[0.05]				[0.53]	[0.03]	[0.02]			
6	−0.10	0.61	1.05	93.84								
	[0.50]	[0.02]	[0.03]									
All					6.79	34.05%					2.63	75.64%

Takeaway

- Identify a slope factor in exchange rates
- High interest rate currencies load more on the slope factor than low interest rate currencies.
- Slope factor explains the cross section of currency returns