Speculative Betas

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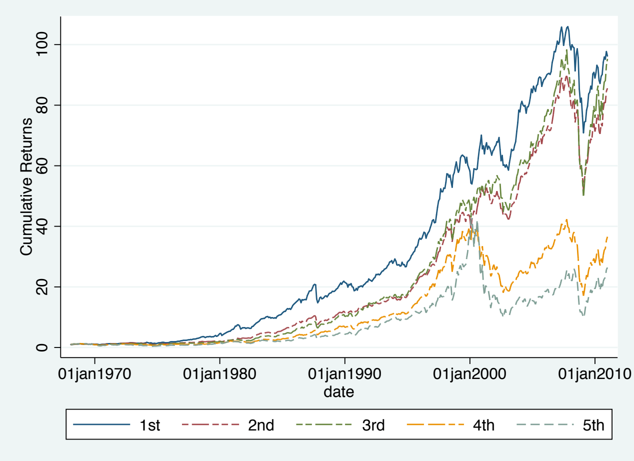
High Risk, Low Return Puzzle



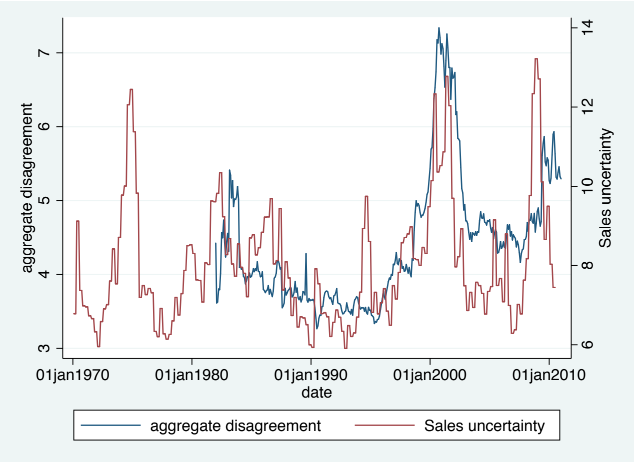
- Beta-neutral strategy of long low beta / short high beta stocks has Sharpe of 0.75 (BBW ('11))
- Black ('72), Pratt ('67), Friend and Blume ('70)

Our Explanation

Disagreement about **aggregate** cash-flows + short-sales constraints

- Non-private information, agree to disagree
- Evidence of disagreement among professional forecasters and households
  - On macroeconomic state variables such as market earnings, industrial production growth and inflation (Cukierman and Wachtel '79, Zarnowitz and Lambros '87, Kandel and Pearson '95, Mankiw, Romer and Wolfers '04)
  - Dispersion in professional forecasts about stock market earnings varies over time and is correlated with aggregate economic uncertainty indicators (Bloom '09, Lamont '02, Yu '10)
  - Disagreement due to heterogeneous priors or cognitive biases such as overconfidence that result in agents over-weighing private signals

Bloom (2012) uncertainty measure and modified Yu (2012) analyst forecast dispersion measure



Short-Selling Constraints

- Short-selling costly due to institutional constraints
- Large fraction of mutual funds, 20 trillion dollars under management, can't short by charter and can't use derivatives (Almazan et al. '04, Koski and Pontiff '99)
- Hedge fund sector with 1.8 trillion dollars can and do short

Key Features of Model

- Otherwise CAPM framework: cashflows of firms follow a one factor model
- Disagree about the mean of common factor and not variances
- Buyers such as retail mutual funds
- Arbitrageurs such as hedge funds who short
- Multi-asset model based on Chen, Hong and Stein 01's rendition of Miller '77 single stock economy
  - Divergence of opinion leads to over-pricing because price reflects only the views of the optimists

The Main Idea

- β scales **aggregate** disagreement

$$\tilde{d}^i = \beta^i \tilde{z} + \tilde{\epsilon}^i$$

1. **High** β assets are **more sensitive to disagreement about aggregate cashflows** than low β assets.
2. Macro-disagreement: optimists $\bar{z} + \lambda$, pessimists $\bar{z} - \lambda$
3. High β experience **more divergence of opinion**: optimist $\beta^i(\bar{z} + \lambda)$and pessimists $\beta^i(\bar{z} - \lambda)$
4. Then **over-pricing** due to short-sales constraints
5. More shorting from arbs on high β

$\Rightarrow$ CAPM holds when aggregate disagreement is low

$\Rightarrow$ But high disagreement leads to inverted-U shaped: initially increasing with beta and then decreasing

- Kinked/concave/inverted-U shaped relationship due to disagreement having to be large enough to over-come benefits of diversification (cost of bearing idiosyncratic risk)

OLG Extension

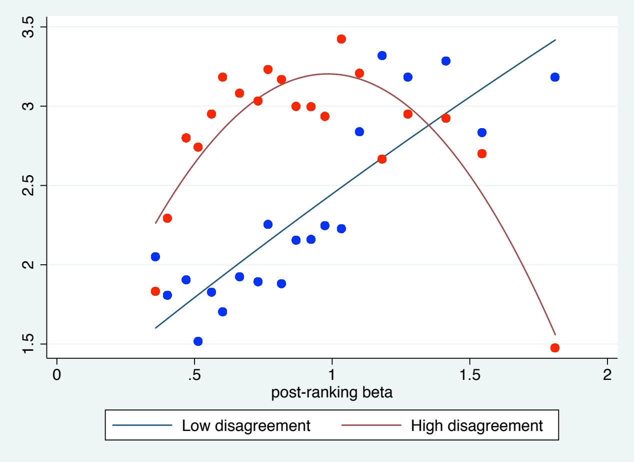
- OLG extension to show results go through + additional implication that high *beta* stocks have higher share turnover
- Calibration exercise

Empirics

- Use modified Yu (2010) measure of dispersion of earnings forecasts and cross-sectional SD of sales growth Bloom '09
- Test basic predictions/premises of the model:
  1. Upward sloping SML when disagreement/uncertainty is low.
  2. Inverted U-shape of SML when disagreement is high
  3. More **stock-level disagreement on high β stocks**, especially when high aggregate disagreement.
  4. More **shorting on high β stocks**, especially when high aggregate disagreement.
  5. More **turnover on high β stocks**, especially when high aggregate disagreement.

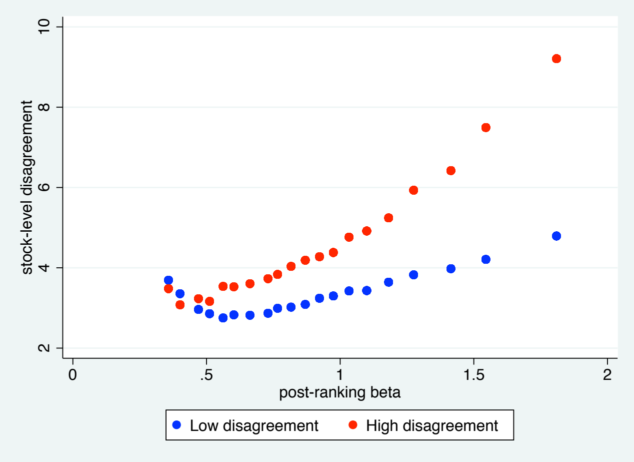
Disagreement and CAPM: kinks

Figure: Average 3-months excess returns for equal-weighted beta decile portfolios in low and high aggregate disagreement months.



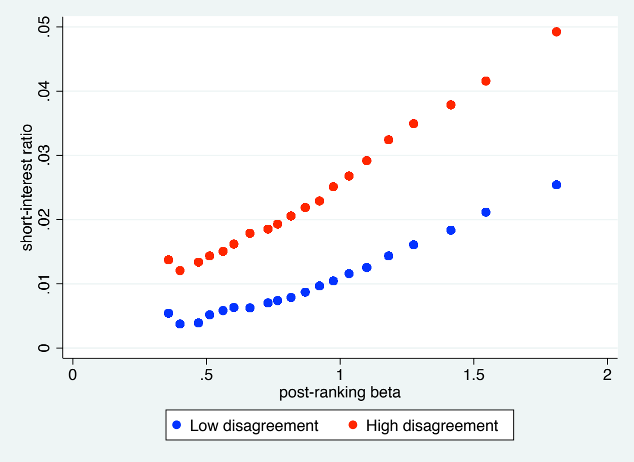
Stock-level disagreement, β and aggregate disagreement.

Figure: Equal-weighted average of dispersion of analyst earnings forecasts by beta deciles during low and high aggregate disagreement months.



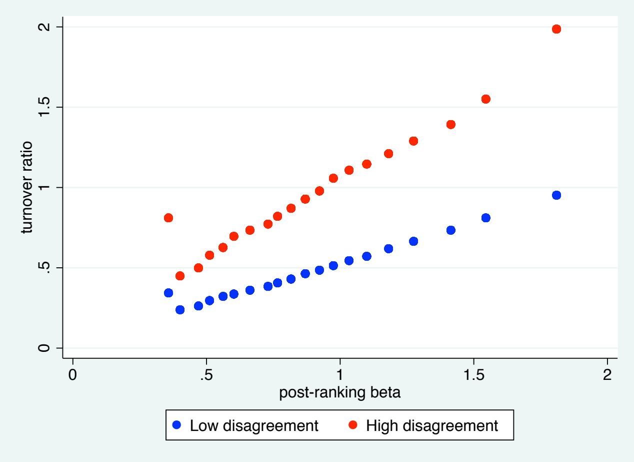
Disagreement, β and shorting activity

Figure: Equal-weighted average of short interest ratio by beta deciles during low and high aggregate disagreement months.



Disagreement and share turnover

Figure: Equal-weighted average of share turnover for stocks by beta deciles during low and high aggregate disagreement months.



Outline

Model

- Dates $t = 0, 1$
- N risky assets and **exogenous** risk-free rate is r
- Risky asset i delivers a dividend $\tilde{d}_i$ at date 1:

$$\forall i \in \{1, \ldots, N\}, \quad \tilde{d}_i = b_i \tilde{z} + \tilde{\epsilon}_i,$$

where $\tilde{z} \sim \mathcal{N}\left(\bar{z}, \sigma_z^2\right)$, $\tilde{\epsilon}_i \sim \mathcal{N}\left(0, \sigma_\epsilon^2\right)$, and $cov\left(\tilde{z}, \tilde{\epsilon}_i\right) = 0$
- Each asset is in supply $\frac{1}{N}$:

$$\boxed{0 < b_1 < b_2 < \cdots < b_N}$$

- Assume $\sum_{i=1}^{N} \frac{b_i}{N} = 1$.

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Investors' Preferences and Beliefs

- Two groups of investors:
  - Short-sales constrained with heterogenous beliefs (MF - fraction α)
  - Unconstrained with homogenous beliefs (HF or arbs - fraction $1-\alpha$)
- Investors have mean-variance utility functions with variance weight $\frac{1}{2\gamma}$ (or CARA withs risk tolerance γ)
- Heterogeneous beliefs about aggregate factor:

$$\mathbb{E}^A[\tilde{z}] = \bar{z} + \lambda \quad \text{and} \quad \mathbb{E}^B[\tilde{z}] = \bar{z} - \lambda \quad \text{with} \quad \lambda > 0$$

- Proportion $\frac{1}{2}$ of optimists/pessimists among SSC agents.
- Investors hold correct expectations about the variance of $\tilde{z}$.

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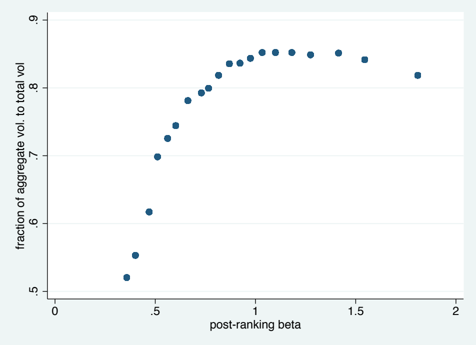
Homoskedasticity

- This is just to simplify the exposition.
- If dividends are heteroskedastic, then need to re-rank assets according to: $\frac{b_1}{\sigma_1^2} < \cdots < \frac{b_N}{\sigma_N^2}$
- In the data, $\frac{b_i}{\sigma_i^2}$ is highly correlated with b_i:

Figure: Sample: CRSP. Period: 1982-2010.



Discussion of other assumptions

1. Can also have disagreement about idiosyncratic but too easy
2. No disagreement on variance/covariance matrix.
   - Jarrow '80: more general structure but less clear implications than 1-factor model
3. Strict short-selling constraints. (realistic – MF)
   - Works with any strictly convex cost function.

Solving for the equilibrium

- Intuition: investors **disagree on expected payoffs**.
  - Mechanically, disagreement is higher for high b assets ($\mathbb{E}^i[\tilde{d}] = b^i \mathbb{E}^i[\tilde{z}]$).
  - Pessimists hit binding short-sales constraints on **high** b **assets first**.

1. Posit equilibrium structure: $\bar{j} \in [1, N]$ such that:
   - Assets $i \geq \bar{j}$ (i.e. $b_i > b_j$) such that pessimists are sidelined.
   - All investors are long assets $i < \bar{j}$.
2. Derive equilibrium pricing equations under $\bar{j}$.
3. Write down conditions under which $\bar{j}$ is the marginal asset.

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Maximization program

- Agents are maximizing:

$$\max_{\mu_i^k} \sum_{i=1}^{N} \mu_i^k \left(b_i \mathbb{E}^k[\tilde{z}] - (1+r)P_i\right)$$

$$-\frac{1}{2\gamma}\left[\left(\sum_{i=1}^{N} \mu_i^k b_i\right)^2 \sigma_z^2 + \sum_{i=1}^{N} \left(\mu_i^k\right)^2 \left(\sigma_\epsilon^2\right)\right]$$

- μ_i^k is number of shares purchased by investors in group k for asset i.
- For agents A and B, under the constraint: $\mu \geq 0$.

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Pricing for "unconstrained" assets

- For unconstrained assets ($i < \bar{j}$):

$$\begin{cases} (\bar{z}+\lambda)b_i - P_i(1+r) = \frac{1}{\gamma}\left(\left(\sum_{k=1}^{N} b_k \mu_k^A\right) b_i \sigma_z^2 + \mu_i^A \sigma_\epsilon^2\right) \\ (\bar{z}-\lambda)b_i - P_i(1+r) = \frac{1}{\gamma}\left(\left(\sum_{k=1}^{N} b_k \mu_k^B\right) b_i \sigma_z^2 + \mu_i^B \sigma_\epsilon^2\right) \\ \bar{z}b_i - P_i(1+r) = \frac{1}{\gamma}\left(\left(\sum_{k=1}^{N} b_k \mu_k^a\right) b_i \sigma_z^2 + \mu_i^a \sigma_\epsilon^2\right) \end{cases}$$

- Market clearing condition: $\alpha\left(\frac{1}{2}\mu_i^A + \frac{1}{2}\mu_i^B\right) + (1-\alpha)\mu_i^a = \frac{1}{N}$
- Pricing equation similar to CAPM:

$$\underbrace{\bar{z}b_i - P_i(1+r)}_{\text{expected excess return on asset } i.} = \underbrace{\frac{1}{\gamma}\left(b_i\sigma_z^2 + \frac{\sigma_\epsilon^2}{N}\right)}_{\text{risk premium}} \quad (*)$$

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Pricing for "constrained" assets

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- With first-order condition:

$$\underbrace{\bar{z}b_i - P_i(1+r)}_{\mathbb{E}[\tilde{R}_i]} = \underbrace{\frac{1}{\gamma}\left(b_i\sigma_z^2 + \frac{\sigma_\epsilon^2}{N}\right)}_{\text{risk premium}} - \underbrace{\pi^i}_{\text{speculative premium}} \qquad (**)$$

Speculative premium

- Speculative premium: excess-pricing over no short-sales constraint benchmark ($\alpha = 0$).
- Derivation: sum FOC and compute $\sum_{k=1}^{\bar{j}-1} b_k \mu_k^B$ using FOC of assets $j < \bar{j}$.
- Exact form (depends on $\bar{j}$ and $\theta = \frac{\frac{\alpha}{2}}{1-\frac{\alpha}{2}}$ strictly $\nearrow$ with α):

$$\pi^i = \theta \left(b_i \frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_z^2 \left(\sum_{i<\bar{j}} b_i^2 \right)} \left(\lambda - \frac{\sigma_z^2}{\gamma N} \sum_{k \geq \bar{j}} b_k \right) - \frac{\sigma_\epsilon^2}{\gamma N} \right)$$

- Speculative premium strictly increases with b_i.

Closing the model: marginal asset

- Derive equilibrium holdings (conditional on $\bar{j}$) of pessimists and derive conditions for:
  1. $\frac{\partial U^B}{\partial \mu^B_{\bar{j}}}(\mu^B) < 0$
  2. $\mu^B_{\bar{j}-1} > 0$
- This is equivalent to:

$$u_{\bar{j}} < \lambda\gamma \leq u_{\bar{j}-1}$$

  where (u) is strictly decreasing sequence.
- We span entire λ space. Unique equilibrium.

Over-pricing

1. Low b assets are priced according to standard CAPM equation.
2. High b assets are over-priced relative to standard CAPM equation. Amount of overpricing increases with λ and α.
   - More disagreement on high b assets – thus more likely to have pessimists short – thus more over-pricing through short-sale costs. (cost of shorting – idiosyncratic risk – is the same accross assets)
   - High b assets are more disagreement sensitive.
3. $\frac{\partial^2 \text{speculative premium}}{\partial \lambda \partial \alpha} > 0$.
   - Increasing λ leads to more severe mispricing in high α environment.
4. Cutoff $\bar{j}$ increases with λ.
   - For high λ, even low b assets can have high disagreement.
5. $\frac{\partial^2 \text{speculative premium}}{\partial \lambda \partial \beta} > 0$: more mispricings when sorted on shorting in high beta stocks

Shorting

There exists $\hat{\lambda} > 0$ such that if $\lambda > \hat{\lambda}$:

1. HFs short at least one asset in equilibrium, i.e. $\mu_N^a < 0$.
2. There exists $\tilde{i}$ such that: $|\mu_N^a| > |\mu_{N-1}^a| \cdots > |\mu_{\tilde{i}}^a| > 0$ and $\forall k < \tilde{i}$, $\mu_k^a > 0$.
3. $\frac{\partial|\mu_N^a|}{\partial\lambda} > \frac{\partial|\mu_{N-1}^a|}{\partial\lambda} \cdots > \frac{\partial|\mu_{\tilde{i}}^a|}{\partial\lambda} > 0$. A rise in aggregate disagreement leads to a larger increase in shorting for high b assets.

OLG Extension

- $t = 0, 1, \dots \infty$
- Each period t, a new generation of mass 1 is born and invest in the stock market to consume the proceeds at date $t+1$.
- A new generation is always compose of 2 groups of agents; arbitrageurs, or Hedge Funds, in proportion $1-\alpha$, and Mutual funds in proportion α.
- Investors have mean-variance preferences with risk tolerance parameter 2γ.
- There are N assets in this economy, whose dividend process each period is given as in our static model by:

$$\tilde{d}^i = b^i \tilde{z} + \tilde{\epsilon}^i$$

OLG Extension

- Mutual funds born at date t have heterogeneous beliefs about the expected value of $\tilde{z}_{t+1}$ and thus about the expected dividend to be received at date $t+1$ before reselling the asset.
- Specifically, there are two groups of mutual funds: group A of optimists MF ($\mathbb{E}^A[\tilde{z}_{t+1}] = \bar{z} + \tilde{\lambda}_t$) and group B of pessimists ($\mathbb{E}^B[\tilde{z}_{t+1}] = \bar{z} - \tilde{\lambda}_t$).
- $\tilde{\lambda}_t \in \{0, \lambda > 0\}$ is a two-states Markov process with persistence $\rho \in]1/2, 1[$.

OLG Extension

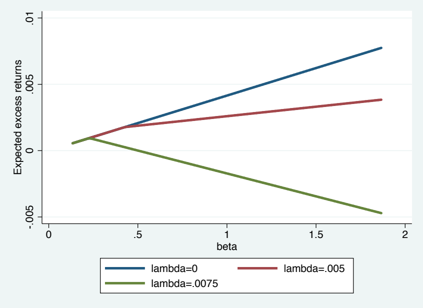
1. When ρ is large, same basic results from static setting.
2. Plus share turnover: high beta stocks have higher turnover due to more shorting and more shares which are then traded when generations changeover.
3. The differential turnover between high w assets ($j \geq \hat{i}$) and low w assets ($j < \hat{i}$) is strictly greater for high disagreement states ($\tilde{\lambda} = \lambda > 0$) than for low disagreement states ($\tilde{\lambda} = 0$).

Resale Option and Bubble

- Suppose $\tilde{\lambda}_t = 0$.
- Potential disagreement at $t + 1$ leads to potential binding constraints when $\lambda > 0$.
- Current generation of traders anticipate that resale price will be high when short-sales constraints are binding in the $\lambda > 0$ state.
- This is a version of the resale option of Harrison and Kreps 1978 and Scheinkman and Xiong 2003 (except each generation has to sell).
- Bubble accompanied by high turnover due to shorting by hedge funds.
- Like classic theories of bubbles with over-trading (too much demand met by arbs shorting)

Illustration: SML Slope Conditional on Disagreement

- Parameters: $N = 100$, $\sigma_z^2 = .0022$, $\sigma_\epsilon^2 = .029$, $\alpha = .63$, $\gamma = .6$, $\rho = 0.94$.



When Some Investors Head for the Exit (w/ Wenxi Jiang)

- Chen-Hong-Stein: Decrease in breadth of mutual fund ownership (change in fraction of MF owners = entry rate - exit rate) forecasts low stock returns
- Asquith-Pathak-Ritter: Top short-interest ratio (shares shorted to shares outstanding) decile under-performs rest of the stocks
- Show exit rate better captures short-sales constraints. Entry rate might reflects changes in limited participation and higher prices and more shorting
- A new measure of hedge fund breadth and exit rate which work better than mutual fund breadth.
- These all work better in high beta stocks, consistent with $\frac{\partial^2 \text{speculative premium}}{\partial\lambda\partial\beta} > 0$.

Short Interest Forecast of Quarterly Returns

1991 to 2008	Sort on short interest ratio									
Equal-Weighted	Raw Return					DGTW Returns				
	Lo Beta	Q2	Q3	Q4	Hi Beta	Lo Beta	Q2	Q3	Q4	Hi Beta
Bottom 50%	2.73%	2.72%	3.43%	2.55%	1.84%	0.32%	0.32%	0.88%	0.50%	0.08%
	(3.22)	(2.93)	(3.28)	(2.00)	(1.05)	(0.74)	(0.90)	(2.89)	(2.09)	(0.14)
Top 5%	1.45%	2.01%	1.47%	0.17%	-0.42%	-0.65%	-0.01%	-0.38%	-1.65%	-2.95%
	(0.89)	(1.29)	(0.93)	(0.10)	(-0.17)	(-0.49)	(-0.01)	(-0.37)	(-2.16)	(-2.47)
Hi - Lo	-1.28%	-0.72%	-1.96%	-2.38%	-2.26%	-0.97%	-0.33%	-1.26%	-2.15%	-3.03%
	(-0.94)	(-0.68)	(-1.84)	(-2.49)	(-2.26)	(-0.74)	(-0.39)	(-1.19)	(-2.56)	(-2.99)

Among high beta stocks, in high disagreement periods (top 30%), Hi-Lo is -2.17% per quarter RAW. In low disagreement periods (bottom 30%) only -1.43% RAW.

Hedge Fund Exit Rate Forecast of Quarterly Returns

1991 to 2008	**Sort on HF EXIT**									
Equal-Weighted	Raw Return					DGTW Returns				
	Lo Beta	Q2	Q3	Q4	Hi Beta	Lo Beta	Q2	Q3	Q4	Hi Beta
Bottom 50%	2.68%	2.76%	3.09%	2.53%	1.93%	0.29%	0.27%	0.61%	0.45%	-0.25%
	(3.21)	(2.88)	(2.98)	(1.95)	(0.94)	(0.68)	(0.84)	(2.64)	(1.66)	(-0.33)
Top 5%	4.00%	2.10%	3.36%	0.78%	-0.63%	2.03%	-0.58%	1.26%	-1.54%	-3.08%
	(4.20)	(2.19)	(2.54)	(0.41)	(-0.31)	(2.65)	(-1.00)	(1.06)	(-1.37)	(-3.02)
Hi - Lo	1.35%	-0.45%	0.53%	-1.65%	-2.44%	1.71%	-0.75%	0.72%	-2.01%	-2.57%
	(2.85)	(-0.86)	(0.62)	(-1.58)	(-2.69)	(2.94)	(-1.45)	(0.66)	(-1.92)	(-2.56)

Among high beta stocks, in uncertain periods, Hi-Lo is -3.24% RAW. It is -2.12% RAW.

Mutual Fund Exit Rate Forecasts Quarterly Returns

1981 to 2008	Sort on EF EXIT									
Equal-Weighted	Raw Return					DGTW Returns				
	Lo Beta	Q2	Q3	Q4	Hi Beta	Lo Beta	Q2	Q3	Q4	Hi Beta
Bottom 50%	3.06%	3.49%	3.54%	3.01%	2.19%	0.12%	0.43%	0.49%	0.20%	-0.48%
	(4.66)	(4.48)	(4.01)	(2.87)	(1.49)	(0.35)	(1.85)	(2.62)	(0.94)	(-0.86)
Top 5%	3.04%	2.77%	2.57%	1.77%	-0.08%	-0.14%	-0.34%	0.43%	-0.56%	-2.36%
	(3.04)	(2.57)	(2.38)	(1.40)	(-0.05)	(-0.18)	(-0.39)	(0.81)	(-0.88)	(-3.19)
Hi - Lo	-0.02%	-0.72%	-0.97%	-1.24%	-2.26%	-0.26%	-0.76%	-0.06%	-0.76%	-1.88%
	(-0.03)	(-1.02)	(-1.56)	(-2.11)	(-3.53)	(-0.37)	(-0.98)	(-0.12)	(-1.25)	(-2.61)

Among high beta stocks, in high uncertainty periods, Hi-Lo is -2.76%. It is -2.58% in low uncertainty periods.

Conclusion

- Bridge of Behavioral Finance to CAPM
- Behavioral Beta Finance or Behavioral Macro-Finance
  - Speculative investors like beta $\Rightarrow$ high beta assets command high prices.
  - High volatility assets associated with higher expected returns.
- Many potential links of existing work back to the cross-section and beta, including capital budgeting implications.