Taking the Art out of Smart Beta

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference
"The Other Place", 8 September 2014

Trinity College and Darwin College

University of Cambridge

Problem Definition

- We revisit last year's smart beta work of Ed Fishwick.
- The CAPM predicts that higher risk portfolios earn a higher return than its lower risk counterparts.
- However, the empirics show the opposite: 'low beta' portfolios outperform 'high beta' ones.
- R_i is the rate of return of asset i, R_m is the rate of return on the market.
- Sharpes market model for excess returns takes the form:

$$r_t = \alpha + \beta r_{mt} + v_t \tag{1}$$

or

$$R_i = \beta_i(R_m - r_f) + r_f + v_t \tag{2}$$

- We shall argue, in terms of the CAPM at least initially, that macro interest rate movements are the main source of the low beta anomaly.

General Outline

- Literature Review.
  - Mismeasurement
  - Unobservables and Leverage
  - Interest term structure and macroeconomic factors
- Theoretical framework.
  - Rewriting CAPM
  - Off-equilibrium movements and APT
  - Term structure
- Model Specifications.
- Data Description.
- Results and Analysis.
- Concluding remarks.

Literature Review

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference
"The Other Place", 8 September 2014

- Causes of 'anomaly' heavily investigated in the literature: could be attributed to many factors.

$$r_i = \beta_i r_m + v_t$$

  Where r_i is the excess return, r_m the excess market return.
- Mismeasurement due to volatility effects and failure to account for risk factors.
- Unobservables and Leverage in Portfolios.
- Risk free rate maturity effects and the yield curve.
- Other approaches including behavioural finance using different risk aversion preferences.

Mismeasurement and Volatility Risk Premia

- Klepfish (2011) and Di Bartolomeo (2013) show that there are substantial differences between arithmetic and geometric returns. (*μ is the actual return)
- The correct method would estimate:

$$E_t(\frac{P_{t+1}}{P_t} - 1) = exp(\mu) - 1 - (\mu - \frac{1}{2}\sigma^2)$$

- This would leave us with:

$$E_t(\frac{P_{t+1}}{P_t} - 1) - E_t(ln(P_{t+1}) - ln(P_t)) = \frac{1}{2}(\mu^2 - \sigma^2) + o(\mu^3)$$

- Scherer (2011) has an excellent paper on this subject. Our work is in line with his, except our framework is essentially CAPM.

Role of Unobservables

- Mispricing because of missing stock specific factors: three factor model by Fama and French (1996).
- Explicit versus implicit leverage: Frazzini and Pedersen (2011) explain the anomaly with borrowing constraints, making explicit leverage strategies costly. Also see Cowan and Wilderman (2011).
- When the relative cost of borrowing increases, implicit leverage strategies are more profitable than explicit ones: investment moves towards high beta portfolios, driving up the price and lowering the return of these products.
- However, the CAPM is an ex ante one period model: implicit leverage boils down to the same portfolio.

Interest Term Structure and Macro Factors

- Expected returns are related to the expectation of interest movements. Caveat: term structure.
- Baele, Bekaert and Inghelbrecht (2010) find that comovement in returns of stocks and bonds is mostly explained by liquidity factors rather than macroeconomic conditions, while Hong, Kim and Lee (2011) find impact of macro factors.
- The Abritrage Pricing Theory (APT) incorporates and finds significance of macro factors (Burmeister, Roll and Ross, 2003), without telling what they are.
- In addition, the magnitudes of target interest rate changes have been constant in absolute value, suggesting that most of the information is captured by sign changes (Goodhart, 2005).

Theoretical Framework

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference
"The Other Place", 8 September 2014

- Rewriting the CAPM reveals its underlying dependence on interest rates.
$$\mu_i = \beta_i \mu_m + (1 - \beta_i) r_f$$
- Off-equilibrium movements and CAPM incompatibility: APT as an answer.
- Potential mismeasurement can occur due to maturity mismatch in interest rates, and a mixed rate has to be considered if investors do not share the same preferences in terms of maturity.

Theoretical Framework: Rewriting the CAPM

Ed Fishwick, Cherry Muijsson and Steve Satchell

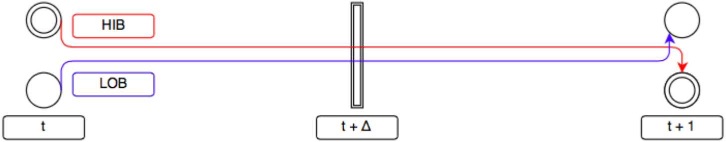
London Quant Group Conference
"The Other Place", 8 September 2014

- Fishwick and Satchell (2014) rewrite the CAPM to show the differing impact of interest rates:
- $$dP_{it} = \frac{-E_t(P_{i,t+1})}{(1 + r_f + \beta(\mu_m - r_f))^2}(dr_f + \beta_i(d\mu_m - dr_f)$$
- and
$$\mu_i = \beta_i \mu_m + (1 - \beta_i) r_f$$
- A fall in the interest rate will lower the expected rate of return for a low beta asset and raise the expected rate of return for a high beta asset (ex ante).
- Flies in the face of high ex-post returns for low beta.

Theoretical Framework: Off-Equilibrium Path

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference
"The Other Place", 8 September 2014



- A possible explanation of this lies in the difficulties of using a one period model with a time series of data.
- APT (Ross,1971 and 1976) allows us to specify more risk factors within a one period model, under the principle that there is no single systematic risk factor but rather a combination of many.

$$\mu_i - r_f = \beta_{i1}(\mu_{m1} - r_f) + \cdots + \beta_{ik}(\mu_{mk} - r_f)$$

- Interest rate risk is identified as a strong potential risk factor, and fits within the APT framework.

Theoretical Framework: Interest Rate Changes

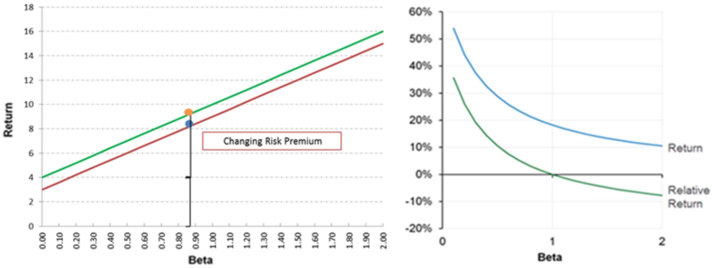


Figure : Market Security Line and Interest Changes

Potential explanation in the gearing that firms underlying the portfolios take on: asymmetric effects.

Theoretical Framework: Term Structure

- One immediate difficulty with the CAPM is that, in its static form, it is not especially informative about what interest rate we should be using.
- Fishwick and Satchell (2014) show that incorrectly assuming a specific rate leads to bias. They propose a model with two types of agents: short rate and long rate investors. They append the CAPM to include wealth-weighted interest rates.
- The interest rate term in the heterogeneous interest rate CAPM becomes $\delta_1 r_{1f} + \delta_2 r_{2f}$, where δ_1 is the relative proportion of risk tolerance weighted wealth of high frequency traders, and δ_2 the proportion of long rate investors. It holds that $\delta_1 + \delta_2 = 1$.
- It then follows that:

$$E(R) - (\delta_1 r_{1f} + \delta_2 r_{2f})\iota = \beta(\mu_m - (\delta_1 r_{1f} + \delta_2 r_{2f}))$$

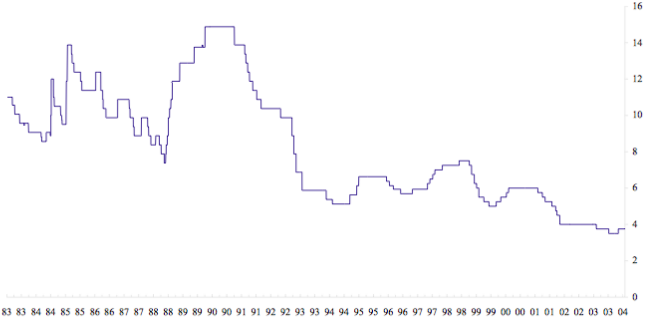
Theoretical Framework: Target Interest Rate

- Therefore, we see that:

$$E(R) - r_{1f}\iota = \beta(\mu_m - r_{1f}) + \textit{ extra interest rate terms}$$

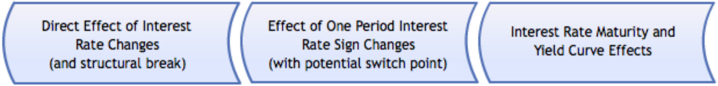
- Effect of cumulative target changes on expectations.

The interest rate target (set by the FOMC) only changed in increments. We see that the changes are similar in magnitude, even for negative and positive changes:



Model Specifications

We can group our estimations in three groups, all of which are estimated using OLS:



- We estimate the 'true' CAPM and the actual interest rate augmented CAPM for each portfolio, checking for interest regime effects with a structural break.
- We look at the impact of interest *sign* changes on each portfolio, assuming that switch point is zero.
- Effects of interest rate maturity mismatch and yield curve effects are analysed in bucket three.
- Robustness checks: time varying version estimates and actual interest sign changes combined.

CAPM and Interest Augmented CAPM

- Sharpe's market model: $r_t = \alpha + \beta r_{mt} + v_t$
- Augmented for interest rates: $r_t = \alpha + \beta r_{mt} + \gamma \Delta r_{ft} + v_t$
- If coefficient γ is significantly different from zero, interest rate changes affect our portfolio returns.
- We expect that there are substantial differences in interest rate sensitivity for high and low beta portfolios.
- We check whether the interest rate regime makes a difference in our returns: $r_t = \alpha + \beta r_{mt} + \gamma i_t^{1983} + v_t$ (as in Fishwick, 2013).

Interest Sign Changes and Switch Points

- However, this fails to take into account why we see asymmetric sensitivity in the two portfolio types.
- The CAPM is a one period model, sign and persistence of interest changes more important than magnitude for expectation.
- Interest rate sign changes:
  $r_t = \alpha_1 i_t + \alpha_2(1 - i_t) + (\beta_1 i_t + \beta_2(1 - i_t))r_{mt} + v_t$
- Where

$$i_t = \begin{cases} 1 & if \, \Delta r_{ft} > 0, \\ 0 & if \, \Delta r_{ft} \leq 0. \end{cases}$$

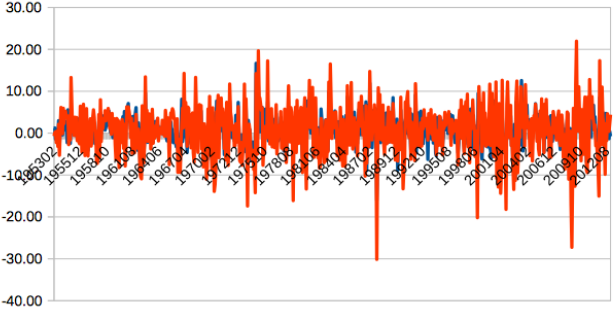
- We check for an estimated reference point using a grid search around the likelihood function and bootstrapping the standard errors.

Interest Rate Maturity and the Yield Curve

- To capture potential yield curve effects, we create a mixed interest rate from the short and long rate and estimate the models using this rate.
- Here, we distinguish between the actual change case and the sign change case: $r_t = \alpha + \beta r_{mt} + \gamma \Delta r_{ft}^{yield} + v_t$
- Mismatch and heterogeneous interest rates for maturity mismatch and composition of traders (δ_1).
- Difference between institutional and retail investors.
- Model: $r_t = \alpha + \beta r_{mt} + \gamma_1 r_{f1t} + \gamma_2 r_{f2t} + v_t$
- Anomaly exists if long rate has a significant impact, and the short rate a coefficient of zero.

Data Description: Portfolios

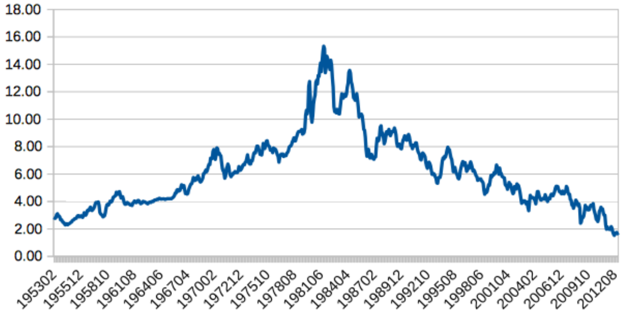
Movement of the high beta (red) and low beta (blue) portfolios over the sample period (1953-1 until 2012-12):



As expected, we can see that high beta portfolios are much more volatile. However, we can also see that negative spikes occured more frequently after 1983.

Data Description: Interest Rate

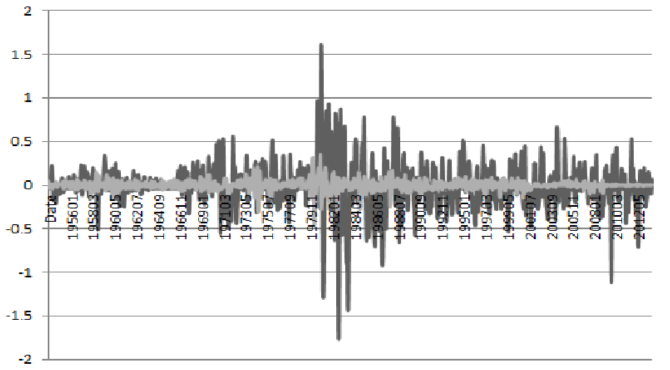
Movements of the ten year interest rate over the sample period (1953-1 until 2012-12):



We see a clear regime change around 1983 for the ten year interest rate: from that moment onwards, interest rates have been declining on average.

Data Description: Interest Rate Volatility

Fishwick and Satchell (2014) test whether a two beta model exists based on a structural break around the crisis.



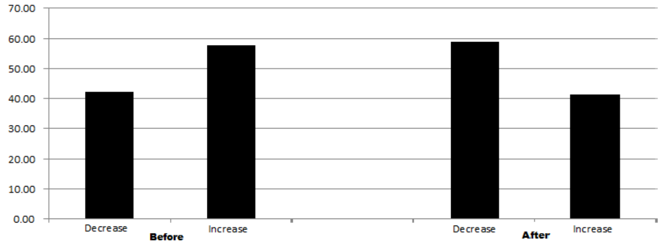
As the CAPM is a one period model, we are interested in the decline over each period rather than the general downward trend in interest rates. We see that long term rates are much more volatile.

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference "The Other Place", 8 September 2014

Data Description: Interest Regimes

The positive sign changes are much more frequent before 1983, and mirrors the negative changes post 1983.



Data Description: Statistics across Methods

Panel 1	*Interest* ↑	*Interest* ↓	*HIB* ↑	*HIB* ↓	*LOB* ↑	*LOB* ↓
Mean	0.016	-0.016	0.568	0.803	0.003	1.354
Standard Dev	0.016	0.018	5.891	5.829	3.514	3.630
Skewness	2.504	-3.224	-0.592	-0.340	-0.533	0.021
Kurtosis	10.903	15.475	3.407	0.880	1.384	1.259

Moments of Ten Year Rate, HIB and LOB Conditional on Interest Changes

Panel 2	*Pre*	*Post*	*HIBPre*	*HIBPost*	*LOBPre*	*LOBPost*
Mean	6.088	6.232	0.666	0.708	0.547	0.825
Standard Dev	2.948	2.553	5.467	6.230	3.445	3.813
Skewness	1.146	0.581	-0.048	-0.747	0.150	-0.495
Kurtosis	0.935	-0.048	0.739	2.883	1.456	1.414

Clearly, the sign change model captures the asymmetry.

Results: Sharpe's and Augmented CAPM

We observe that alpha is significantly positive for low beta portfolios: $r_t = \alpha + \beta r_{mt} + \gamma \Delta r_{ft} + v_t$

Panel 1[2]	α	$t(\alpha)$	R_m	$t(R_m)$	ΔR_f	$t(\Delta R_f)$	R^2	-
Equation (4)								
HIB	-0.007	-0.102	1.274	81.138	-	-	0.902	-
LOB	0.307	4.096	0.696	40.857	-	-	0.699	-
Equation (5)								
HIB	-0.011	-0.154	1.282	81.324	10.740	3.569	0.903	-
LOB	0.313	4.254	0.681	40.267	-17.585	-5.448	0.711	-
Panel 2[3]	α	$t(\alpha)$	R_m	$t(R_m)$	$\Delta(R_f)$	$t(\Delta(R_f))$	R^2	–
Sample Break								
HIB	-0.061	-0.612	1.273	80.863	0.113	0.792	0.903	-
LOB	0.404	3.911	0.702	40.982	-0.201	-1.332	0.711	-

The estimates are of opposite sign, which confirms our hypothesis. Also, the structural break in the sample is insignificant.

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference "The Other Place", 8 September 2014

Results: Sign Changes in the Interest Rate

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference
"The Other Place", 8 September 2014

The sign change model is significantly different from the baseline. Interestingly, the asymmetry between high and low beta can be captured by a double alpha model.

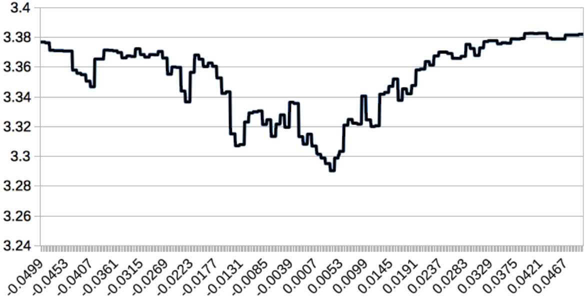
Panel 3[4]	α	$t(\alpha)$	R_m	$t(R_m)$	i_t	$t(i_t)$	$i_t R_m$	$t(i_t R_m)$
Equation (6)								
HIB $\beta\alpha$	-0.270	-2.852	1.273	57.730	0.545	3.977	0.011	0.347
HIB α	-0.280	-2.928	1.278	82.087	0.551	4.053	-	-
Equation (6)								
LOB $\beta\alpha$	0.766	7.381	0.693	29.466	-0.923	-6.321	-0.010	-0.297
LOB α	0.770	7.496	0.688	41.424	-0.929	-6.402	-	-

Panel 4[5]	α_1	$t(\alpha_1)$	α_2	$t(\alpha_2)$	R_m	$t(R_m)$	R^2	-
Double Alpha								
HIB	0.269	2.789	-0.282	-2.928	1.278	82.087	0.904	-
LOB	-0.159	-1.540	0.770	7.496	0.688	41.424	0.716	-

$$r_t = \alpha_1 i_t + \alpha_2(1 - i_t) + (\beta_1 i_t + \beta_2(1 - i_t))r_{mt} + v_t$$

Results: Threshold Estimation of Sign Changes

We check for the robustness of the model by estimating the threshold: we run a grid search along the likelihood function of the model, and bootstrap the standard errors to estimate the minimum point.



We find that the zero reference point is accurate.

Results: Yield Curve and Heterogeneous Rate

We should find that the short rates are insignificant and the long rate positive as the shares δ_i are positive by definition.

$r_t = \alpha + \beta r_{mt} + \gamma_1 r_{f1t} + \gamma_2 r_{f2t} + v_t$

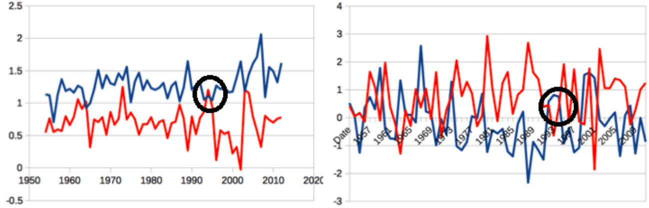
Panel 6	α	$t(\alpha)$	R_m	$t(R_m)$	R_{f1}	$t(R_{f1})$	R_{f2}	$t(R_{f2})$
Equation (7)								
HIB	-0.147	-2.096	1.281	80.540	10.580	3.467	-0.390	-0.353
LOB	0.467	6.210	0.682	39.965	-17.286	-5.280	0.142	0.119

Panel 8	α	$t(\alpha)$	R_m	$t(R_m)$	ΔR_f	$t(\Delta R_f)$	i_t	$t(i_t)$
Yield Curve								
HIB	-0.110	-1.221	1.273	80.954	0.972	0.891	-	-
LOB	0.310	-4.092	0.701	40.840	-1.062	-0.900	-	-
HIB	-0.283	-1.252	1.272	81.231	-	-	0.243	1.732
LOB	0.481	-4.762	0.702	41.402	-	-	-0.381	-2.560

The anomaly cannot be explained by a misspecification of interest rates for this specific sample, at least for the proportions δ we show.

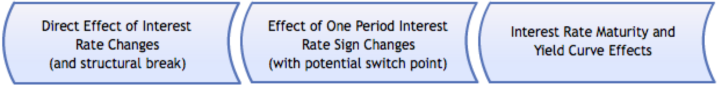
Results: Time Variation in Estimates

We estimate the time varying coefficients by rolling the sample window (without overlap). Results for high (blue) and low (red) beta are presented.



The intersection in 1994 is matched by an intersection of alphas (where low beta has the higher alpha normally): 1994 was a year where interest rates were raised significantly after economic recovery.

Results: Back to Buckets



- Actual interest changes do not explain the differences between portfolios, and there is no evidence of a structural break.
- Interest sign changes explain the heterogeneous impact through a double alpha effect. Also holds in time varying setup, and even in summary statistics show the return advantage of low beta portfolios.
- The 'anomaly' does not seem to be related to maturity mismatch and yield curve effects.
- **Interest sign changes might explain the 'anomaly': macroeconomic movements affect portfolios.**

Concluding Remarks

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference "The Other Place", 8 September 2014

- We show that there is a double alpha effect for both portfolios using a sign change specification of interest rates.
- This approach is validated by the one period specification of the CAPM.
- Alpha is positive (negative) for high (low) beta portfolios when the interest rate increases, and vice versa.
- Interest rate maturity misspecification is not an explanation for the anomaly in this sample.
- Exogenous macro factors causing out of equilibrium movements seem to drive the anomaly.

Link to Previous Research

- Scherer did extensive research on extended factor models and their applications to asset pricing.
- Our results are in line with Scherer in that it is probable that an extended factor model explains a fair bit.
- This is related to the APT version of the CAPM:

$$\mu_i - r_f = \beta_{i1}(\mu_{m1} - r_f) + \cdots + \beta_{ik}(\mu_{mk} - r_f)$$

- We find, surprisingly, that whilst interest rate changes seem linear and signifcant in both high and low beta portfolios, interest sign changes affect HIB symmetrically but clearly asymmetrically for LOB.

Practice: Where Do We Go From Here?

Ed Fishwick, Cherry Muijsson and Steve Satchell

London Quant Group Conference "The Other Place", 8 September 2014

- Reasons why this asymmetry emerges are not entirely clear and we cannot offer definite answers.
- One possible explanation is the fact that policy-related interest changes tend to be constant; thus the magnitude of changes are effectively irrelevant for shaping reactions. It is the sign that matters.
- Also, the impact of repeated changes is clearly not independent (persistent) and there is a cumulative effect on expectations, certainly in recent times.
- Even though the short rate is the policy instrument, we find that long rates drive equity returns; this might be due to the role of the long rate in discounting earnings leading to heightened equity sensitivity.

Thank you for your attention.

Vote for us!

London Quant Group Conference
Oxford, 8 September 2014