Business 35150 **John H. Cochrane**

Problem Set 8 answers

Part II Hedge fund problem

Regressions $R^e_{t+1} = a + bR^e_t + \varepsilon_{t+1}$

serial correlation of hedge fund returns and factors

return	b = rho	t	R2	v ratio
rmrf	0.11	1.75	0.013	1.364
hml	0.11	1.78	0.013	1.449
smb	-0.07	-1.15	0.006	0.728
umd	0.07	1.16	0.006	1.147
def	0.46	8.01	0.212	1.706
term	0.05	0.70	0.002	0.641
HFIndex	0.20	3.09	0.039	1.529
ConvArb	0.55	10.17	0.303	2.747
ShortBias	0.09	1.32	0.007	0.821
EmergMkt	0.30	4.97	0.094	1.847
EquitMktNeut	0.05	0.82	0.003	1.169
EventDriven	0.35	5.88	0.127	2.079
Distress	0.39	6.48	0.150	2.316
Multi-Strat	0.31	4.97	0.094	1.930
RiskArb	0.25	3.95	0.062	1.158
BondArb	0.53	9.59	0.279	2.552
GlobalMacro	0.07	1.15	0.006	1.305
LongShtEqty	0.19	3.00	0.036	1.313
MgdFuture	0.03	0.48	0.001	0.613

The factor correlations are small and only def is really significant The rmrf serial correlation and 1.4 ratio are luck of the draw with this dataset. They disappear in longer data, and actually if anything go the other way.

My table has some extra factors that are part of a problem you didn't do, to examine hedge funds with multifactor models. Two things might be at work with def. First, high yield bond returns may well be serially correlated in short samples, as put option returns are. Second, I approximated the returns to BAA bonds as the change in yields times a 5 year duration. You may be seeing the value of real data!

Almost all the hedge fund indices are more correlated than the factors. That's the point.

The hedge fund index isn't that bad. Some of the styles though, are hugely autocorrelated. Convertible arb, with notoriously illiquid investments is huge at 0.55 with a t stat of 10.2 (!), which is Medoffian serial correlation. Event driven, distress, bond arb are also huge. Global macro and managed futures are the small ones, and they use very liquid securities.

Beyond liquidity and slow marking, returns can appear correlated when the strategies have option-like returns. A string of long gains and a huge loss will look correlated over time in a short sample that hasn't seen the full range of big losses.

The last number is the variance of one year returns divided by the variance of one month returns times 12, $var(r_t + r_{t+1} + .. + r_{t+12})/(12 \times var(r_t))$. This is called the "variance ratio" test. If returns are uncorrelated over time, the variance ratio should be one. (Remember the first problem set, where you proved that for uncorrelated returns $var(r_t + r_{t+1} + .. + r_{t+12}) = 12 \times var(r_t)$. If returns are positively correlated over time (momentum) this is greater than one – long-run returns are more risky than the short-run returns indicate. If returns are negatively correlated (mean-reversion) the variance ratio is less than one.

(To see why, let $\gamma_j = cov(r_t, r_{t+j})$. Then $var(r_t + r_{t+1} + .. + r_{t+12}) = var(r_t)\,[12 + 2 \times (11\gamma_1 + 10\gamma_2 + ... + \gamma_{12})]$. If all the γ are positive, this is greater than $12var(r_t)$ and vice versa.) This is a nice test for unstructured positive or negative correlation at many lags. As you can see most of the numbers are greater than one and some are huge.

```
a) Replicate asness -- capm on overall index in short sample
Date range from  1 31 1994 to 9 30 2000
  Monthly returns
                     E(rx)  s(rx) Sharpe Annual ( tstat)
            HFIndex   0.67   2.88   0.23   0.81 (  2.10)
               rmrf   1.18   4.21   0.28   0.97 (  2.53)
```

Hedge funds look pretty good. Both mean and standard deviation are about half the market, so the Sharpe ratio is almost the same. If the beta is zero, as claimed, it's very very good.

b) The regression:

```
                     betas
                     E(rx)  alpha   t(a)   rmrf     R2 a-Sharpe   s(e)
            HFIndex   0.79   0.27 ( 1.01)  0.40   0.36   0.12   2.27
                     std errors
                     E(rx)  alpha  rmrf     R2
            HFIndex   0.31   0.27   0.06   0.36
```

As Asness claims, beta×E(rmrf) soaks up a lot of alpha! The beta of about 0.40 multiplied by the 1.18 (last table) market premium soaks up most of the 0.79% mean return. (This mean is a little larger because I left off three data points, so that the lags that come next would use the same sample.) The alpha is now statistically insignificant and the alpha sharpe ratio (information ratio) is cut in half.

c) Betas with lags:

```
betas with   0.00  leads and   3.00       lags
                     E(Rx)  alpha   t(a)  rmrf     R2 a-Sharpe   s(e)
            HFIndex   0.79  -0.21 (-0.74)  0.80   0.47  -0.10   2.07
                     E(Rx)  alpha   t(a)  rmrf   -1     -2     -3       R2
            HFIndex   0.79  -0.21 (-0.74)  0.43   0.12   0.20   0.05   0.47
```

This table shows as beta the sum of the three lags. The beta has doubled to 0.80, so that now alpha is negative!

c)

```
  Annual betas
                       E(rx)  s(rx)  alpha   t(a)   b,rmrf    R2 a-Sharpe  s(e)
              HFIndex  11.18  11.21  -0.10 (-0.03)  0.61   0.29  -0.05   9.44
```

Here I'm using annual data. The HF mean return is 11%. We get a 0.61 beta. Longer horizons also are less sensitive to slow marking.

d), e)

```
  up/down betas with 0 leads and lags
                       E(Rx)  alpha  rmrf+  rmrf-     R2
              HFIndex   0.79   0.87   0.24   0.57   0.38

 up/down betas with   0.00  leads and   3.00       lags
                       E(Rx)  alpha  rmrf+  rmrf-     R2
              HFIndex   0.79   1.19   0.44   1.23   0.52
```

There is a strong difference between up and down betas! The down betas are more than double the up betas.

Of course the alphas are no longer intercepts, so meaningless

Here is the same result, with the three lags and the current one displayed separately. (I didn't ask for this)

```
                    showing all  lags
                       rm-3+  rm-2+  rm-1+    rm+  rm-3-  rm-2- rm-1-1    rm-
              HFIndex  -0.15   0.12   0.12   0.34   0.23   0.31   0.16   0.54
                     showing all lags together and current
                       rlag+    rm+  rlag-    rm-
              HFIndex   0.10   0.34   0.69   0.54
```

The lags are almost all on the downside! The lagged up beta is only 0.08 of 0.37 current. On the downside, lags are 0.69 with 0.54 current! It looks like Asness' "slow marking" is "slow recognition of losses."

3. Asness in subsequent data

```
Comparison to data after 2001
Date range from  1 31 1994 to 9 30 2000
  Monthly returns
                       E(rx)  s(rx) Sharpe Annual ( tstat)
              HFIndex   0.67   2.88   0.23   0.81 (  2.10)
                 rmrf   1.18   4.21   0.28   0.97 (  2.53)
```

```
Date range from  10 31 2000 to 12 31 2013
                      E(rx)  s(rx) Sharpe Annual ( tstat)
             HFIndex   0.39   1.55   0.25   0.87 (  3.18)
                rmrf   0.33   4.66   0.07   0.25 (  0.90)
```

On top, I remind you of the previous result. On the bottom, the new result. Hedge funds still look pretty good. Ok, the average return is about half, but so is volatility, so the Sharpe ratio is still astonishingly (suspiciously – survivor bias?) good at 0.87 annualized. Meanwhile the market has been terrible; the 1.18% monthly return is only 0.33% since 2001. This lower market return is a key in what follows so pay attention.

```
                   betas
             E(rx)  alpha   t(a)   rmrf     R2 a-Sharpe   s(e)
HFIndex   0.41   0.31 ( 3.49)  0.23   0.47   0.28   1.12
                   std errors
             E(rx)  alpha  rmrf     R2
HFIndex   0.12   0.09   0.02   0.47
```

The contemporaneous beta is down to 0.23 from 0.41.

```
             betas with   0.00  leads and   3.00       lags
             E(Rx)  alpha   t(a)  rmrf     R2 a-Sharpe   s(e)
HFIndex   0.41   0.28 ( 3.35)  0.32   0.56   0.27   1.03
             E(Rx)  alpha   t(a)  rmrf   -1     -2     -3       R2
HFIndex   0.41   0.28 ( 3.35)  0.22   0.07   0.05  -0.02   0.56
```

Lagged betas still matter, raising beta from 0.23 to 0.32 – but nowhere near the 0.80 we had before. But again, alpha is still almost the same as mean return. Why? *Because the market stank.* $\beta \times E(rmrf)$ can't do anything with a lousy $E(rmrf)$.

$\Rightarrow$We're also up to 56% R^2! This is a big difference. Even though the alphas are surviving (but full of bias) the idea of $\beta = 0$ hedge funds is silly!

```
            Annual betas
             E(rx)  s(rx)  alpha   t(a)   rmrf     R2 a-Sharpe   s(e)
HFIndex   5.26   8.04   3.33 ( 2.43)  0.35   0.74   3.24   4.07
```

Once again, the annual horizon picks the lagged beta effect. The R^2 is up to 74%!! This very high R^2 means that $\sigma(\varepsilon)$ is small, so the alpha sharpe ratio is big.

```
          up/down betas with 0 leads and lags
           E(Rx)  alpha  rmrf+  rmrf-     R2
HFIndex     0.41   0.47   0.18   0.27   0.48

up/down betas with   0.00  leads and   3.00       lags
           E(Rx)  alpha  rmrf+  rmrf-     R2
HFIndex     0.41   0.33   0.29   0.32   0.56
        showing all  lags
           rm-3+  rm-2+  rm-1+    rm+  rm-3-  rm-2- rm-1-1    rm-
HFIndex     0.01   0.03   0.03   0.22  -0.06   0.06   0.10   0.23
         showing all lags together and current
           rlag+    rm+  rlag-    rm-
HFIndex     0.08   0.22   0.09   0.23
```

There's a bit of difference with up/down betas at 0 lag; it disappears with 3 lags. The slower marking of down betas disappears too.

In sum, what happened to Asness et al? Lagged betas still matter. A much larger amount of the hedge fund index represents beta risk – 60%-80% R^2. Beta itself declined, but idiosyncratic risk declined even more. However, since the market did so badly and hedge funds did not, average returns are still alpha. The up/down character seems to have disappeared in the overall hedge fund index. Many of the styles do still show option-like characteristics (equity market neutral for example!)

4. Here are the fund statistics FYI (I only asked for average returns)

```
3. full sample, CAPM only

  Monthly returns
                      E(rx)  s(rx) Sharpe Annual ( tstat)
             HFIndex   0.49   2.10   0.23   0.80 (  3.60)
             ConvArb   0.38   1.92   0.20   0.69 (  3.09)
           ShortBias  -0.59   4.77  -0.12  -0.43 ( -1.93)
            EmergMkt   0.46   4.15   0.11   0.38 (  1.72)
         EquitMktNeut   0.23   2.85   0.08   0.28 (  1.26)
          EventDriven   0.55   1.77   0.31   1.07 (  4.78)
             Distress   0.63   1.85   0.34   1.17 (  5.24)
          Multi-Strat   0.51   1.92   0.27   0.92 (  4.13)
              RiskArb   0.29   1.15   0.26   0.89 (  3.98)
              BondArb   0.22   1.60   0.14   0.48 (  2.14)
           GlobalMacro   0.70   2.69   0.26   0.90 (  4.04)
           LongShtEqty   0.57   2.77   0.20   0.71 (  3.17)

                  rmrf   0.62   4.52   0.14   0.47 (  2.12)
```

By and large most indices have equity-like volatility. Mean returns vary widely, but most are significant and large. Annual Sharpe ratios are huge, compared with the 0.37 market Sharpe ratio. If only it weren't full of selection bias...

	betas with 3.00 lags				up/down betas with 3.00 lags					
	E(Rx)	alpha	t(a)	rmrf	R2	a-Sharpe	s(e)	rmrf+	rmrf-	R2
HFIndex	0.52	0.27	(2.58)	0.41	0.44	0.17	1.55	0.33	0.45	0.44
ConvArb	0.39	0.20	(1.77)	0.31	0.23	0.12	1.69	0.45	0.16	0.27
ShortBias	-0.63	-0.10	(-0.57)	-0.81	0.68	-0.04	2.70	-1.05	-0.66	0.68
EmergMkt	0.45	0.06	(0.29)	0.60	0.36	0.02	3.30	0.39	0.69	0.36
EquitMktNeut	0.24	0.01	(0.06)	0.37	0.16	0.00	2.63	0.07	0.54	0.24
EventDriven	0.55	0.29	(3.64)	0.41	0.55	0.24	1.19	0.33	0.43	0.56
Distress	0.63	0.36	(4.24)	0.43	0.52	0.28	1.27	0.29	0.49	0.54
Multi-Strat	0.51	0.25	(2.70)	0.41	0.47	0.18	1.39	0.37	0.41	0.48
RiskArb	0.29	0.20	(3.16)	0.14	0.33	0.21	0.94	0.14	0.14	0.33
BondArb	0.24	0.07	(0.71)	0.28	0.22	0.05	1.41	0.18	0.29	0.26
GlobalMacro	0.75	0.63	(3.71)	0.20	0.08	0.25	2.54	0.07	0.28	0.09
LongShtEqty	0.60	0.25	(2.10)	0.54	0.57	0.14	1.80	0.64	0.49	0.58

The HF index now has results intermediate between the two samples above, as you might expect. 3 lag betas are 0.41. There is some indication that down betas are more than up betas. Note though that the R^2 with up/down betas doesn't increase much.

For all styles, except risk arb and global macro, the betas are substantial, and even those aren't zero.

For most styles, the R^2 are surprisingly high as well, averaging in the 30 - 50% range. The idea any of these is "market neutral" is silly.

Some standouts. Short bias has a big negative beta. It's nice to confirm beta means something!

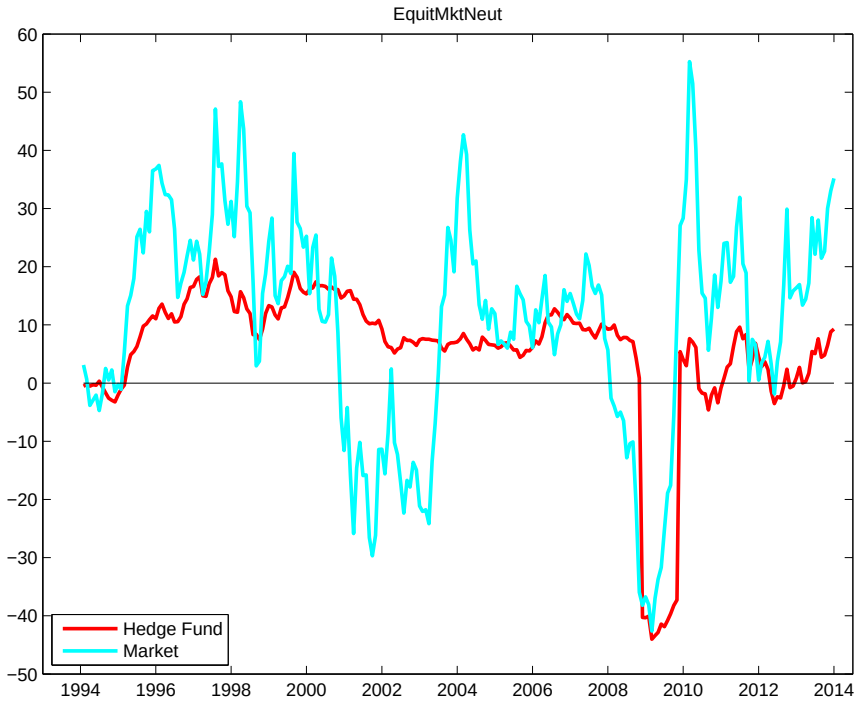
Emerging market has a 0.60 beta. This is a great warning about labels vs. betas. "We'll find a new asset class" does not mean "we'll get a lot of diversification."

Equity market neutral, event, distress, multistrat and long-short equity all sound like hedged zero beta equity strategies. They all have betas in the 0.40 - 0.50 range.

Even the bond strategies, bond arb, conv arb, have decent betas.

Most of the down betas are bigger than the up betas. Not all.

The standout is "equity market neutral" with a 0.07 up beta and 0.54 down beta. It's about as pure a put option writer as you can get. Here's a graph of it's performance at an annual basis. Note you had to wait 20 years to really see there was a steamroller behind the nickels. There was no up/down beta in the data up to 2008. Regression analysis can be very slow to pick up option-writing exposure!



4. Here are my results

betas x premiums/E(rx) with 0.00 leads and 3.00 lags

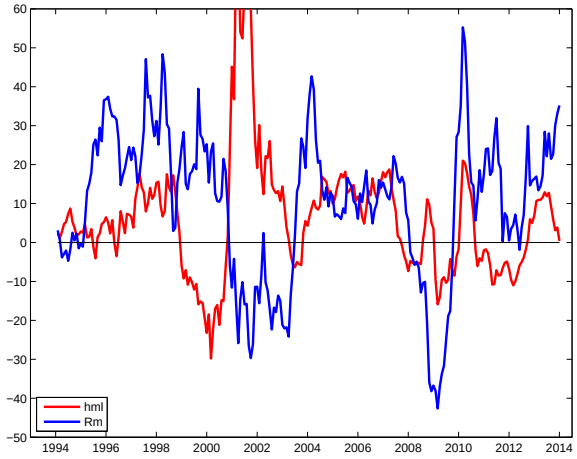
	E(Rx)	alpha	t(a)	rmrf	hml	smb	umd	term	def	R2	a-Sharpe	s(e)
HFIndex	0.52	0.11	(1.06)	0.46	0.01	0.05	0.10	0.10	0.06	0.58	0.08	1.34
ConvArb	0.39	0.11	(1.06)	0.28	-0.02	0.08	-0.05	0.20	0.23	0.48	0.08	1.39
ShortBias	-0.63	-0.03	(-0.19)	0.73	-0.03	0.21	-0.04	0.10	-0.07	0.77	-0.01	2.31
EmergMkt	0.45	0.09	(0.37)	0.67	-0.05	0.16	0.02	-0.07	0.04	0.43	0.03	3.10
EquitMktNeut	0.24	-0.07	(-0.47)	0.74	0.22	-0.13	0.27	-0.15	0.38	0.48	-0.04	2.07
EventDriven	0.55	0.25	(2.97)	0.42	0.05	0.06	0.01	-0.00	0.01	0.63	0.23	1.08
Distress	0.63	0.30	(3.34)	0.40	0.06	0.04	-0.02	0.02	0.02	0.60	0.26	1.16
Multi-Strat	0.51	0.22	(2.26)	0.42	0.04	0.10	0.04	-0.03	0.01	0.57	0.17	1.26
RiskArb	0.29	0.19	(2.81)	0.29	0.01	0.09	-0.07	0.07	-0.04	0.43	0.22	0.87
BondArb	0.24	-0.01	(-0.12)	0.44	0.01	0.03	0.02	0.15	0.39	0.51	-0.01	1.11
GlobalMacro	0.75	0.31	(1.72)	0.25	0.06	0.03	0.07	0.18	0.00	0.22	0.13	2.34
LongShtEqty	0.60	0.14	(1.39)	0.52	-0.06	0.07	0.14	0.05	0.03	0.79	0.11	1.28

Overall, this is a surprising bust. Most of the explaned expected returns comes form market betas. Equity market nuetral is the only one with a serious amount of value – 22% – on top of a large 74% from rmrf, which is why it has a negative alpha when we're all done. Short bias, emerging, and multistrat have a bit of smb exposure which makes sense. Equity market nuetral has a 27% exposure to mometum, which makes sense too. Term and Def, convertible arbitrage has decent exposures, as does bond arbitrage, with an espeically big def exposure. Interestingly, so does equity market neutral.

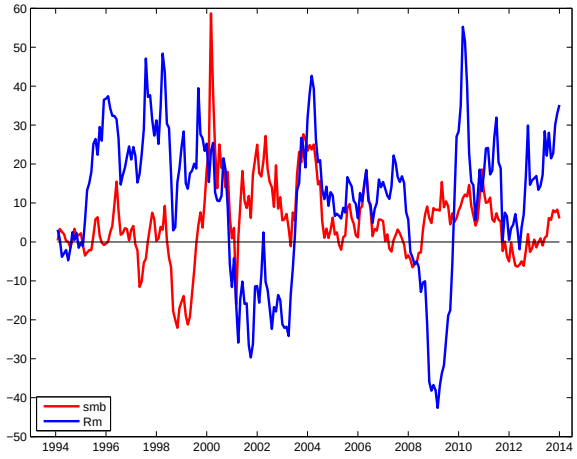
Extras

I find one-year return graphs insightful. I can't see much in one month returns, but NAV graphs wander off too far.

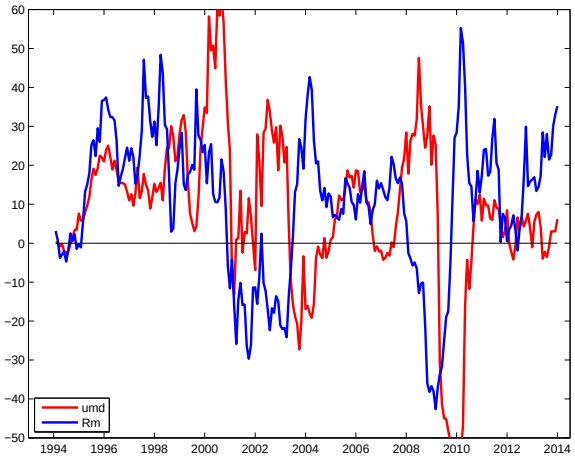
In evaluating the multiple regressions it's worth thinking what information the different factors have, and when they moved historically. You get a big hml beta if you did well in pone of hml's big moves.



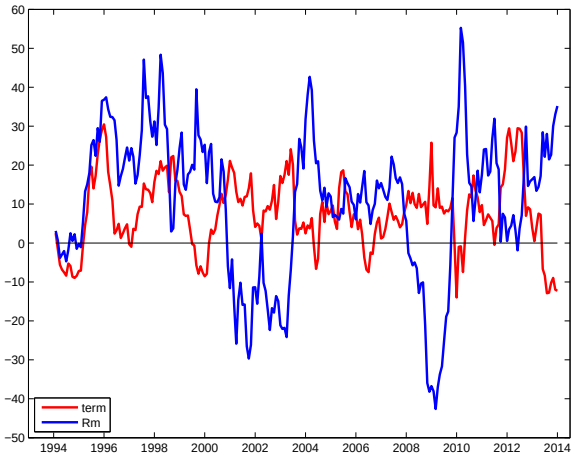
hml is basically uncorrlated with rmrf. It's big loss was shorting growth in the 1990s, its big gain was shorting growth in 2000. Up and down in the crisis



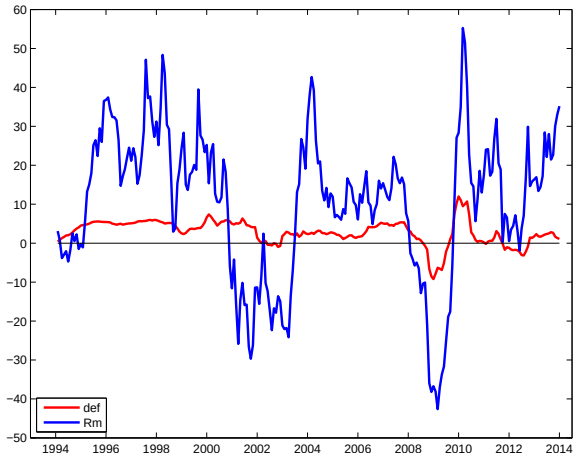
smb is basically uncorrelated with both hml and rmrf. The initial part of the crisis was not good for small or value firms. Small stocks did badly in the 1990s, well in the late stage of the boom, but tanked when the boom tanked.



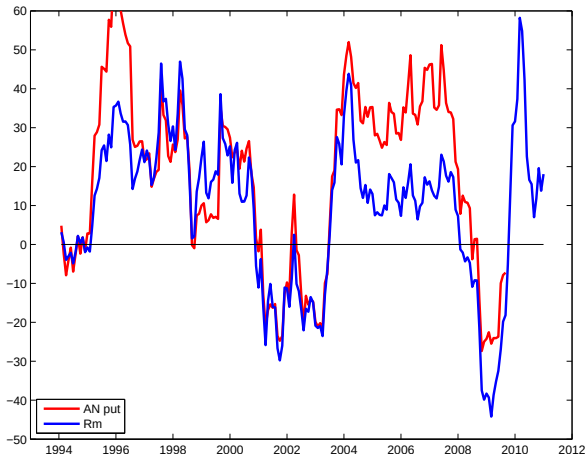
Momentum is really weird. It apparently did well in the crisis, but every fund I know was hurting. Maybe the funds were deleveraging so the trade got better. Interestingly momentum got destroyed in the recovery. I wonder how momentum funds are doing.



This looks boring, but it follows what you ought to know about interest rates For example, the interest rate declines of the financial crisis are good for long term bonds; their carry increased and their prices increased.



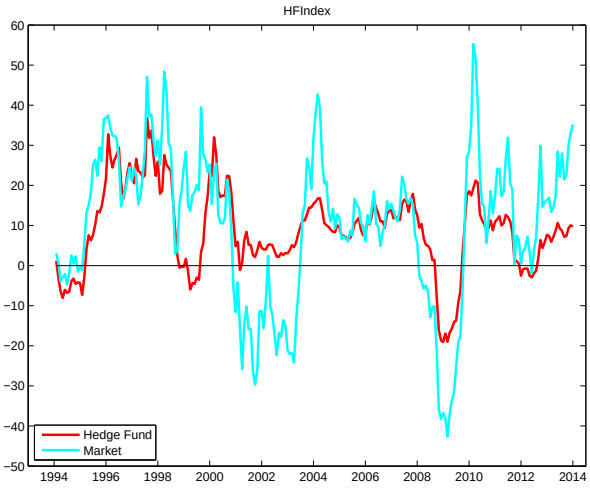
Credit is in many ways like writing a put option. Buying high yield bonds can't do better than the yield, but can do a lot worse if the company defaults. You see pennies in front of a steamroller until the steamroller hits in 2002 and 2008. Then buying credit in Dec-Mar 2008 was a once in a lifetime opportunity, so credit made a big profit. You see def moves a bit before the market, which is the main way you'd tell a credit beta from a market or market option beta (i.e. hard to do.) It's also a market return forecaster.



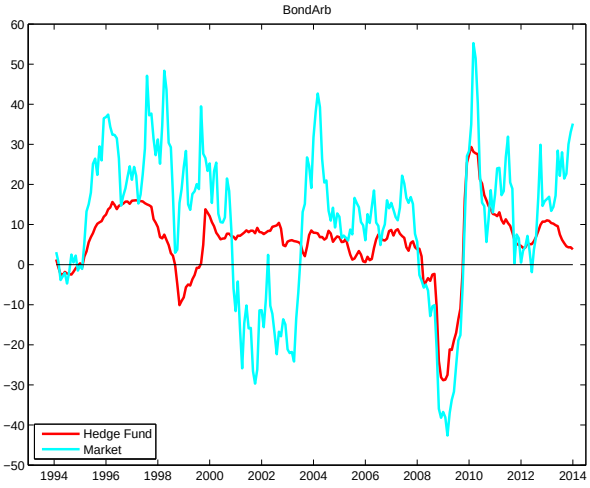
This is the annual return on the Aggarwal Naik put writing strategy discussed above. I'm still waiting for a better strategy.

0.1 One year return graphs of hedge funds

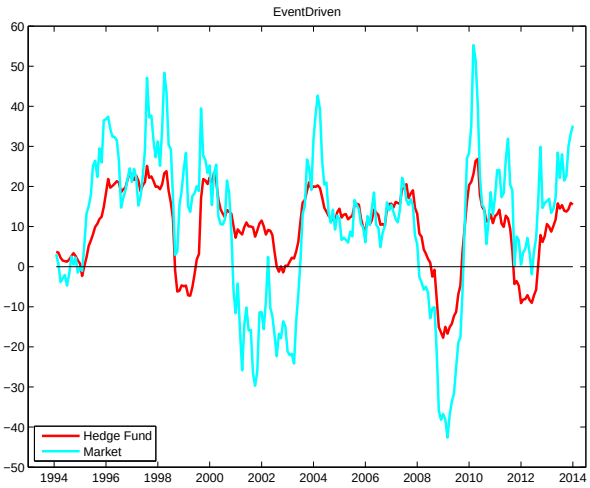
Here are plots of one- year returns. I think these show the market betas most clearly. Don't forget there are other factors too! To do the other factor attribution you sort of have to remember how the other factors moved relative to rmrf.

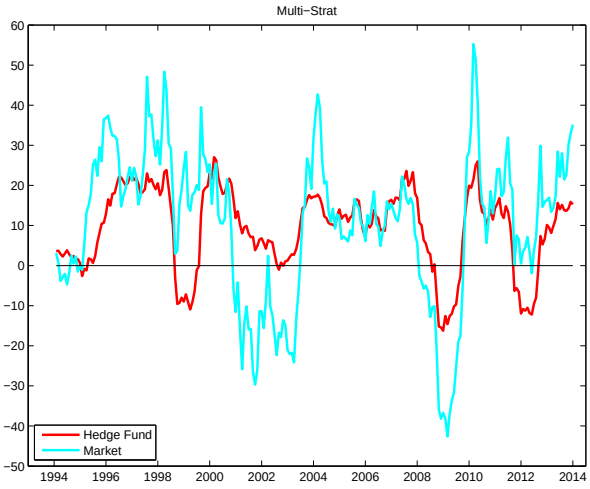


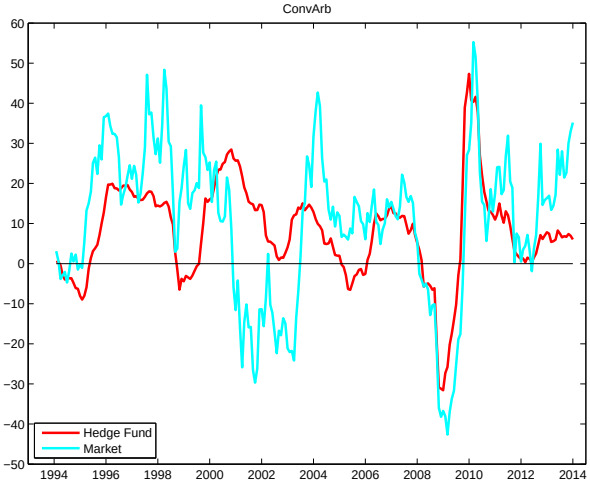
A good case for substantial beta. Avoiding 2002 is genius if real

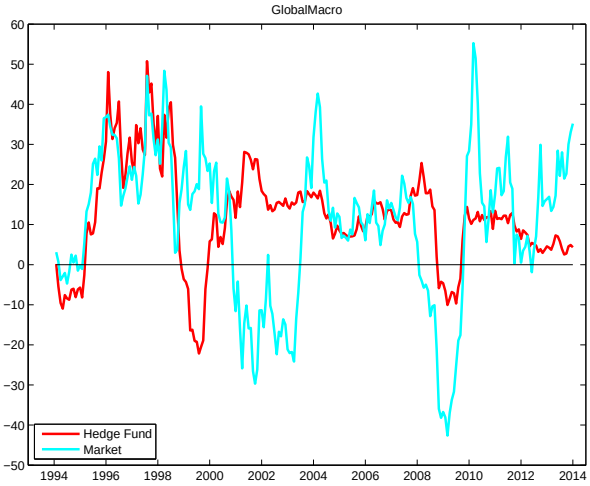


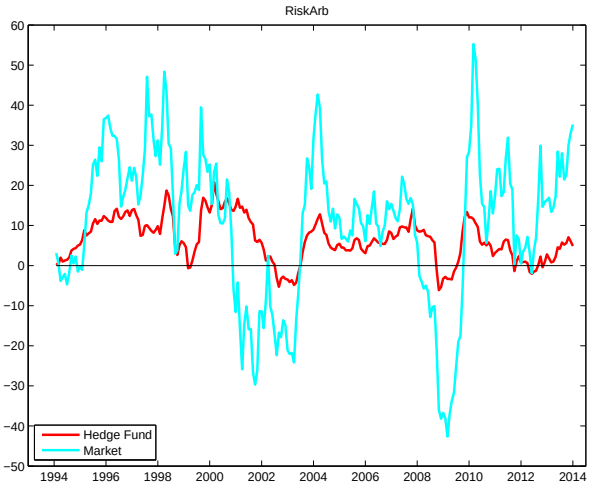
Super-smoooth returns except in 1998 and 2008. This looks a lot like put option writing.

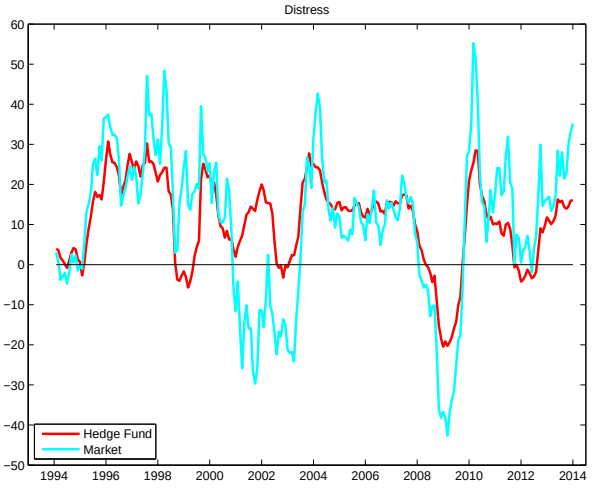


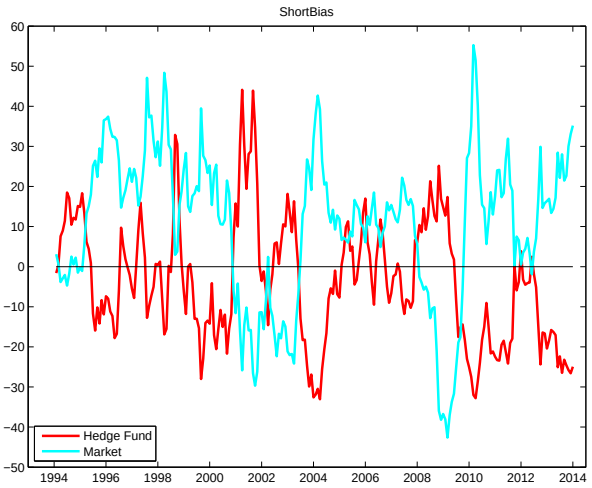

Multi−Strat
Hedge Fund
Market

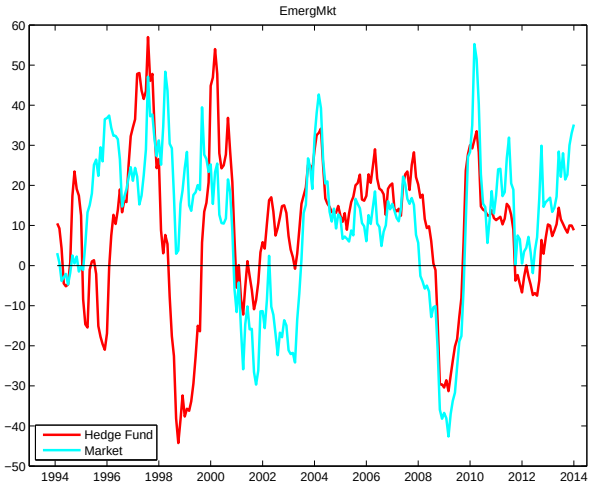

ConvArb
Hedge Fund
Market

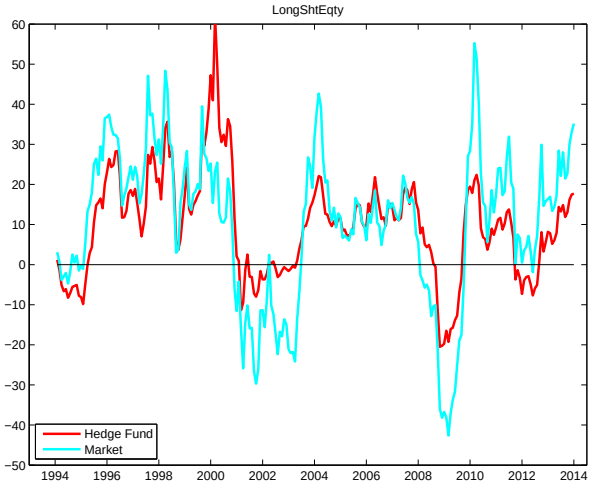

GlobalMacro
Hedge Fund
Market

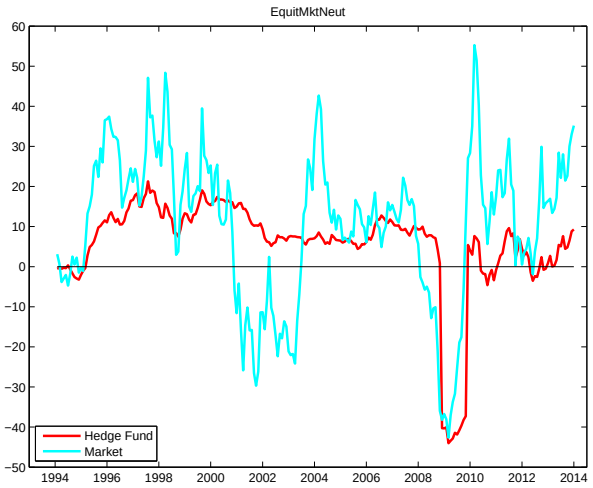

RiskArb
Hedge Fund
Market


Distress
Hedge Fund
Market

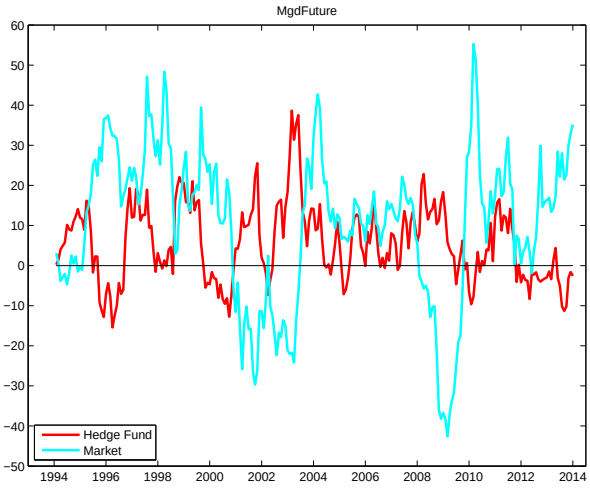

ShortBias
Hedge Fund
Market







Except if the market tanks. This is a way out of the money put option


MgdFuture
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Hedge Fund
Market